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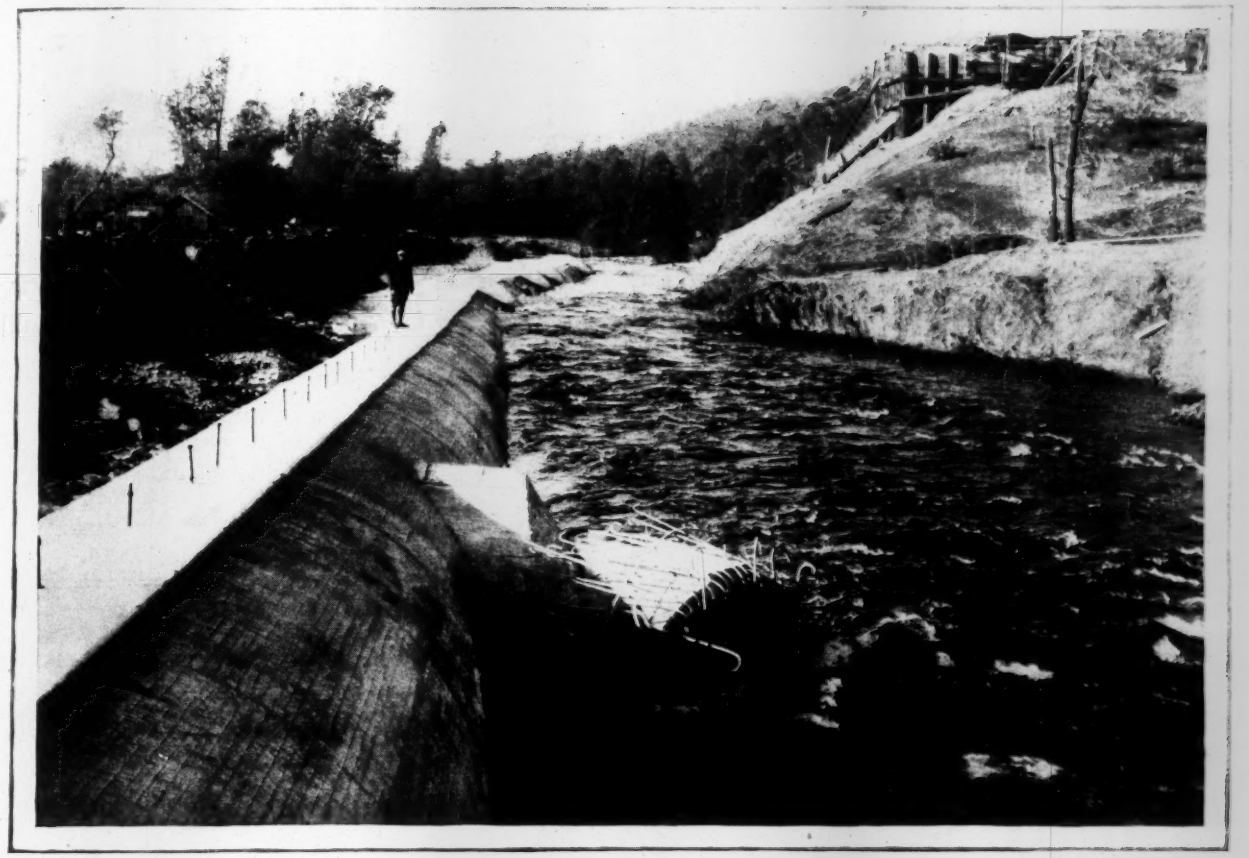

Conduit Through Site of Moccasin Reservoir Dam, Hetch Hetchy Water Supply System

Construction Progress on Hetch Hetchy Aqueduct

Road Builders Require New Soil Studies

Expansion Joints in Wilson Dam Closed by Asphalt Grouting

Harsh Aggregates Used in Concreting the Toltec Dam

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The Road to Plenty

CIVIL engineers and contractors will have a special interest in the review in this issue of Foster and Catchings' book, "The Road to Plenty." The authors conclude that construction work is the only balance wheel available to prevent economic depression. This conclusion—not a new one—has been discussed at various times in these columns, most recently in the issue of March 1. Foster and Catchings advocate the setting up of a continuing statistical inquiry that will give us early warning that the consuming power is shrinking, relative to productive capacity. By prompt stimulation of public-works construction, they argue, the consuming power will be increased and the portending trouble avoided. There is no need here to rehearse the difficulties and the promise of the proposal. Suffice it to say that those engaged in construction will gain a new view of the importance of their work by seeing how this inquiry in economics leads back to their industry as holding the key to the solution of one of the world's great economic problems.

Westward Ho

AT LAST winged man has crossed the north Atlantic on the westward passage. The "Bremen" adventurers succeeded where their predecessors failed, and the reward of courage and skill is their due. They knew that other planes and crews had set out only to disappear without a trace. Whether magnetic aberration had lured them into the frozen wildernesses or whether tremendous storms had overwhelmed them, the bold three could not guess, but they dared, and they won. Thus Europe regains part of the glory that was taken from it by the Western Continent when Lindbergh flew across; when, 435 years after Columbus' adventure, he claimed for America the crown of daring seamanship, held throughout the ages by men who had voyaged toward the setting sun. The achievement of the Genoese led to centuries of mastery of the seven seas by Europe. The future holds the secret of mastery of the air. Will it remain with the eastward or with the westward fliers?

Swift Couriers

IN EUROPE, air transportation of passengers has developed so rapidly under large government subsidies that Americans who go there come back with the impression that America is falling behind in the application of flying to its transportation needs. Development here, however, is not so backward as these travelers would have us believe. Here, where distances are much greater and where the subsidies are lacking which in Europe make flying cheap enough for the average business man or pleasure seeker, efforts to develop commercial flying have been concentrated on the carriage of mails. Quietly, without the public attention which passenger airplane services attract, airplane-mail routes have been established east and west, north and south across this country until most of the important cities can now be reached by airplane post. The whole country benefits, often without knowing it. A case in point is the report of the failure of the St. Francis dam in our issue of March 22. The use of photographs and drawings to illustrate Mr. Bowers' telegraphic report of the accident was made possible only by the air-mail service between New York and Los Angeles. With a regularity approaching that of railway mail, by night as well as day, in fog, in rain or snow, these couriers complete their appointed rounds, totaling a mileage of flying experience which keeps this country at least abreast of Europe in the development of aviation.

Heat Loss in Chuting

THE winter concreting operations on the Toltec dam which are described in this issue exhibit a number of variations from ordinary winter practice. Concreting in winter in the thin, dry air and high winds of 8,000 ft. elevation is not usual. Again, the use of frozen aggregates and the application of heat solely by torch, within the mixer drum, are exceptional. Finally, the engineer adds another figure to the sparse records of temperature losses in placing concrete by means of long chute lines. It is a common charge that chute placing in cold weather offers special hazards because of the enormous radiation losses of the heated concrete in flowing through long stretches of open trough swung high in the air. Yet inquiry discloses almost no record of how rapidly concrete loses heat in its chute travels. This deficiency of rational planning data, in a concreting procedure so commonly employed as is chuting, makes even the occasional specific determination of values, like that at the Toltec dam, highly important.

Chicago's Bond Issues

A GENERAL and growing distrust of the present city administration of Chicago was the main reason for overwhelming defeat of a long list of proposed bond issues voted on at the election on April 10. Suspicion of the excessively large bond-issue ballot was a factor contributing to the defeat. This ballot listed 31 separate bond issues, aggregating nearly $78,000,000. Of this great total $48,500,000 was for continuing important street widenings and improvements already authorized and commenced; these were lost with the other proposed works in the wholesale rejection of the bond issue. It is reported that this list of ten projects may again be submitted for vote in June, some attempt being made in the meantime to explain their importance and to secure public confidence. The next largest group comprised twelve new projects, with a total of $21,000,000 for the initial work only. But the public had been given to understand that these bond issues were premature, that the estimates

were guesses and that the final costs of the completed projects were unknown but would amount to enormous sums. A third group, nine projects totaling $7,800,000, was for additional street lights, traffic-control lights, fire-engine stations and other miscellaneous work; several of these projects also were under suspicion. Some civic associations publicly recommended negative votes on all the projects. Others recommended a select few for approval, but the general trend of disapproval was so strong as to result in total defeat. On the other hand, two bond issues by the Lincoln Park Commission were approved, though with only small majorities. These provide $2,000,000 for additional lake front improvements and $2,000,000 toward the new bridge at the mouth of the Chicago River. The unfortunate total defeat of the city's bond-issue plans is an indication of what may result from political methods and loss of public confidence on the part of a city administration.

Growth by a Power Law

WE LIVE at so rapid a pace that most of us are hardly aware of the vastness of the processes of growth manifest in our communities. At best those few individuals who have occasion to study governmental expenditures have remarked on the expanding budgets and rising taxes of cities and states. But the huge dimensions of the physical development back of such financial statistics are little appreciated. Recent data from a number of cities on their paving, sewerage and other essential improvement works indicate staggering totals of millions, especially for such large communities as Los Angeles, St. Louis or Detroit. They give a clue to the factors of present-day growth. Reflection will show that the tendencies of today toward concentration of population and industrial activities bring about an increased need for public works in a ratio far larger than that of population growth. There is probably something like a higher-power formula in action, which makes the physical demands of a community triple or quadruple for a doubling in size. Water and sewer mains must be larger as well as longer. Wire networks are subject to increased intensity of use per connection as the number of connections increases. And even paving and transportation costs seemingly go up in a power ratio. Thus government and utility service will show a steadily mounting cost per inhabitant. Up to the present, both the efficiency of the services and the producing power of the community have kept pace with this increased expense loading. So long as this process continues, public works will grow toward still larger magnitudes.

Earth's Physical Bonds

IN THE marvelous facts and figures of the world's new activity in building roads there is much to lure the mind away from sound logic. Yet in no field is there greater need of solid reasoning, in order that the work may be dealt with constructively. We must appreciate fully and precisely the part which the road plays in modern life, but we may not at our peril overvalue it. Overvaluation is a danger that lies close at hand. Thus, recently an orator in glorifying the work of the present day pointed to the fact that from remotest antiquity roads have been the main factor in the world's development; by tying peoples and countries together they formed the physical bonds of the populated world. And he therefore reasoned that the present great highway-building age is a time of reshaping and rebonding the earth, and that the modern paved highway integrates great regions just as the Via Appia and the rest of the Roman military road system united the civilized world into one great empire. Engaging as is the picture he sketched, we think it contains more romance than fact. The roads of olden times bonded the earth together by creating arteries of commerce, by providing a smooth wagonway in place of footpath and packtrail. But today that great service is performed by the railroad, and all the wonderful growth of highways in the past two decades has done nothing to alter this fact. If roads were the physical bonds of the world of 2,000 years ago, railroads are the bonds of the modern earth. The present-day highway thus is not the true successor of the great main roads of antiquity. That is not to deprecate it, for the modern road is vastly important. It is a marvel of human achievement, but only by flight of fancy can we liken it to those great channels of commerce that dominated the activities of past ages. The day may come perhaps when the highway will again occupy that remarkable place, but it is not yet here. Rhetorical fancy which misinterprets the true function of the modern road cannot serve as basis for constructive thought on today's highway questions.

State Control of Cities

CONTROL of metropolitan populations by the electorate of the state presents one of the most intricate and baffling problems of political organization. So often the work of the engineer is tied up with extra-municipal or regional commissions or boards representing part or whole of a metropolitan district that he is particularly affected and should be interested.

A little less than a year ago the Mississippi was in flood and New Orleans adopted the heroic measure of cutting the levee at Caernarvon, just as—so the tourist visitor is told—will always be done before letting the water come over the city's levees. To get permission to blow up the levees the city had to appeal to local, state and national authorities and its financial backers had to promise to assume the responsibility for all damages and to bring into the city the inhabitants of the area to be flooded. The latter was done, though not without difficulty, threats and injunction. The trappers and market garden people were well cared for, well housed and fed and the children provided with school facilities. Damages to the property have been practically all determined by an arbitration board and the New Orleans Levee Board stands ready to foot the bills. But before the necessary bonds can be issued a constitutional amendment must be obtained.

For this purpose a state election was set for April 17. At the same time the entire electorate of Louisiana was called upon to approve three other constitutional amendments, all relating to New Orleans affairs. One of the other amendments is required to permit the Sewerage and Water Board of New Orleans to issue some $9,000,000 of bonds to increase the drainage facilities so seriously taxed last April, as outlined in our issue of Dec. 22, 1927, p. 1002. The richest city in the valley is thus hampered in meeting the cost of last year's protection against the flood and in providing for future safety.

To lessen this onerous state control over New Orleans one of the proposed constitutional amendments includes several provisions that will enable the city to make certain imperative public improvements without first obtain-

ing one or more amendments to the Louisiana Constitution.

Several other states have inhibitions which, though materially different, tie their cities hand and foot. So the farmers and villagers of up-state New York and down-state Illinois control the financing of important public-benefit improvements in New York and Chicago. Appointments to port and park commissions are too often kept under state control, largely to provide a means for paying off political obligations.

Whether the voters of Louisiana relinquish their stranglehold on New Orleans remains to be seen. Surely the state Legislature of Illinois will not soon give up the right to say what maximum tax rates are to be. New York City also will remain under state tutelage, though it is gaining some relief through the enlarged home-rule powers resulting from recent constitutional amendments.

What, then, is to be the solution of the problem? Is it essential to have checks on so-called city extravagances and refinements, when the city people are willing to pay the bills? Prof. Charles E. Merriam, of the University of Chicago, recently suggested making half a dozen of the large metropolitan cities of the country into new states. This proposal is thought-provoking, but has at best remote likelihood of being adopted. North and South Dakota split up in the early days of scant population, meager and slow transportation. North and South California and East and West Texas are subdivisions not unthinkable. But proposals for the metropolitan states of Chicago and New York have never yet received more than amused comment.

Much has been done and more will follow in the way of metropolitan districts, with joint powers over water, sewers, parks and transit and in some parts of the country over flood protection. The last is often so large a problem, geographically, as to make necessary for effective action an aggregation of counties or parts of several states into large units, as in the Mississippi alluvial area. Flood-control costs and benefits might then be assessed on the whole as a conservancy district. This form of governmental development may be far in the future or near at hand. Meanwhile the attempt of the New Orleans Sewerage and Water Board to get out from under the thumb of the State of Louisiana is a matter of more than local interest.

Detection of Transverse Fissures

SAFETY of railway traffic continues to be threatened by the presence of transverse fissure in rails and it is disconcerting to find that records show an increasing number of rail failures due to this class of defects. Many theories as to their cause have been evolved, but none has been proved to be correct. Attempts to prevent fissures from developing have been fruitless and until the present time attempts to detect them have been equally unsuccessful. Now it appears that a definite advance toward successful detection has been made. A new method of locating fissures in rails in the track has been developed which eliminates many of the defects of former devices.

What is the primary cause of this type of defect in steel rails has not yet been determined positively, but it appears to be connected with the manufacturing processes. Under the influence of strain resulting from traffic, the defect develops until, if not discovered in time, it leads to fracture of the rail. The rapidity of this development increases with increasing wheel loads and traffic, factors which accentuate the strain set up in the head of the rail. Rail failures become more frequent when loads are increased beyond some undetermined figure, a figure which no doubt also bears some relation to the weight of rail. One railroad considers an axle load of 60,000 lb. as the maximum for 100-lb. rails.

An early step toward detecting transverse fissures was the use of mirrors in track inspection for examining the underside of the rail head. It was tedious and uncertain in its results and could be successful only in detecting fissures which had developed to such an extent as to reach the surface of the rail, at which time their location is indicated by a telltale streak of rust. Experiments with magnetic testing apparatus, in which the head of the rail was passed through a magnetic field, failed to give satisfactory results. The apparatus recorded a miscellaneous variety of defects without discriminating between those within the steel and those resulting from such external causes as blows with spike mauls or "burning" by the slipping of driving wheels.

About two years ago E. A. Sperry, of gyroscope fame, devised an electric testing apparatus in which a strong current at low voltage was passed through short sections of the head of the rail. Interference with the flow of this current through the rail head—due to the minute gaps caused by transverse fissures—was magnified enormously in a recording instrument. This device marked an advance over the somewhat similar magnetic device in that only transverse fissures caused the current interruptions that are recorded.

So successful were the laboratory tests made with this device that upon the recommendation of the American Railway Engineering Association an appropriation for the building of a test car was made by the American Railway Association last year. This car was completed recently and has been put through some preliminary track tests. A description of it is given elsewhere in this issue. While the track tests have not been as successful as had been hoped, they have been sufficiently so to warrant their continuance and to promise results of practical value. Doubtless further improvement will come with more extensive experience.

So far so good. The problem of detecting transverse fissures appears to be in a fair way to be solved. But one detector car, or even a dozen cars, cannot make bad rails safe. Transverse fissure detection is not enough. The ultimate aim must be prevention, because, unless the trouble is attacked at its source, fissures always will be present either in incipiency or in various stages of development. This is known to be true of rails already in track and is believed by many to be true of rails yet to be laid or still in process of manufacture. Tests of new rails at the mills, by the device mentioned, may throw light on the early history of the transverse fissure defect. Responsibility for prevention lies chiefly with the manufacturer, and he must be looked to for help and co-operation. That a campaign for prevention must be pushed to a successful issue is certain, since it is not conceivable that the railways must be compelled to continue using rails which possibly contain elements of disaster. Observation of the relation between the development of transverse fissures and the weight of rail and wheel load also is important and must be carried on systematically with the detection work. Together such studies may make it possible to avoid dangerous rail service conditions and to work toward the ultimate end of eliminating fissures by removing the cause.

Construction Progress on Hetch Hetchy Aqueduct

Work Approaching Completion on 17 Miles of Foothill Tunnels—Shafts Completed for 30-Mile Coast Range Tunnels—Pipe Line Across San Joaquin Valley Not Begun

THE HETCH HETCHY AQUEDUCT for the water supply of San Francisco, Calif., is 156 miles long from the Hetch Hetchy reservoir, formed by the O'Shaughnessy dam in Yosemite National Park, to the city distribution system. Of this aqueduct 21.4 miles from the reservoir to the Moccasin power plant and the portion crossing San Francisco Bay have been completed. The portion between these two end sections comprises mainly two groups of tunnels—the foothill tunnels and the Coast Range tunnels—and a pipe line across the San Joaquin Valley between tunnels. The following article describes the progress of construction on these divisions. The construction progress to the point where the present article takes it up was described in *Engineering News-Record*, June 18, 1925, p. 1021. —EDITOR.

TUNNEL driving in the foothill division of the Hetch Hetchy aqueduct, San Francisco's mountain water-supply project, is almost completed. This division, 16.7 miles long, is practically all tunnel, the driving of which has been carried on with notable freedom from interruption. The work is being done, partly by contract and partly by city forces, from ten headings, the first of which was started in February, 1926. A map and profile of the aqueduct under construction or not yet begun is shown by Fig. 1.

Completion of the foothill division will bring the new Tuolumne River water supply to the east side of the main San Joaquin Valley, whence two major projects, the 47.4-mile pipe line across the valley and the Coast Range division (including 28.6 miles of tunnel), remain to be constructed. For these two remaining steps a $24,000,000 bond issue is to be voted on May 1, and if this carries, the construction program is arranged to deliver the mountain water supply to the city mains by 1932. Purchase of the distribution system of the private water company is under consideration and a $41,000,000 bond issue for this purpose will also be voted on at the May 1 election.

The net tunnel length in the foothill division is 15.85 miles, of which 8.60 miles is being built by city forces and 7.25 miles by contract. These tunnels will convey water from the tailrace of the Moccasin Creek power house to Oakdale Portal, on the eastern side of the San Joaquin Valley. The section was designed for 400 m.g.d. on a hydraulic grade of about 0.0012 with the tunnel full and under pressure. Some excess of possible flow over that figured is provided by driving the tunnel on a 0.0015 grade. Concrete lining will be put in on about 40 per cent of the total length. The lining is to have a minimum thickness of 6 in., will not be reinforced except for a few special sections in soft ground and will require an average of about 2 cu.yd. per lineal foot.

Cross-sections of two sizes were used, 10½ and 14¼ ft high, respectively, both of horseshoe shape, as shown by Fig. 2, the size difference being that required to compensate for the difference in smoothness of lined and unlined sections. In rock formations where it was uncertain at the outset whether the ground would permit the lining to be omitted, the practice was to drive first the bore of smaller size and then, if it developed that the larger section was permissible for distances long enough to avoid too frequent changes from lined to unlined section, the additional work of enlarging the excavated section by about 3 ft. in height and width was done on one side and the roof. The cost of this enlarging has been about $10 per lineal foot.

The chart, Fig. 3, showing progress combines on one diagram the time and rate of advance at each heading, as well as a curve (the heavy dotted line) showing the amount and rate of advance on the tunnels of the division as a whole. The same vertical time scale applies to all the curves on the chart. The horizontal scale is likewise applicable to all curves, the figures lettered thereon representing distances in 100-ft. units from the zero point of the foothill division survey, and showing for the dotted curve total progress for all headings as measured from the right side of the chart as a zero point. The uniform slope of the progress curve on the chart indicates the notably steady rate of advance that has prevailed in this division.

As a part of the foothill division, the so-called Moccasin reregulating reservoir is being constructed at the

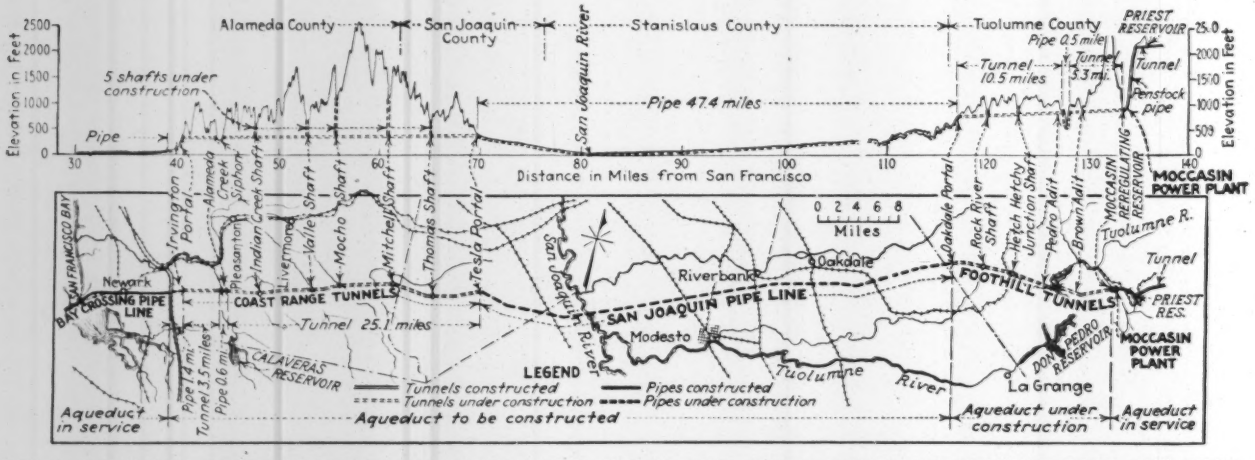


FIG. 1—PLAN AND PROFILE OF FOOTHILL, SAN JOAQUIN AND COAST RANGE DIVISIONS OF HETCH HETCHY AQUEDUCT

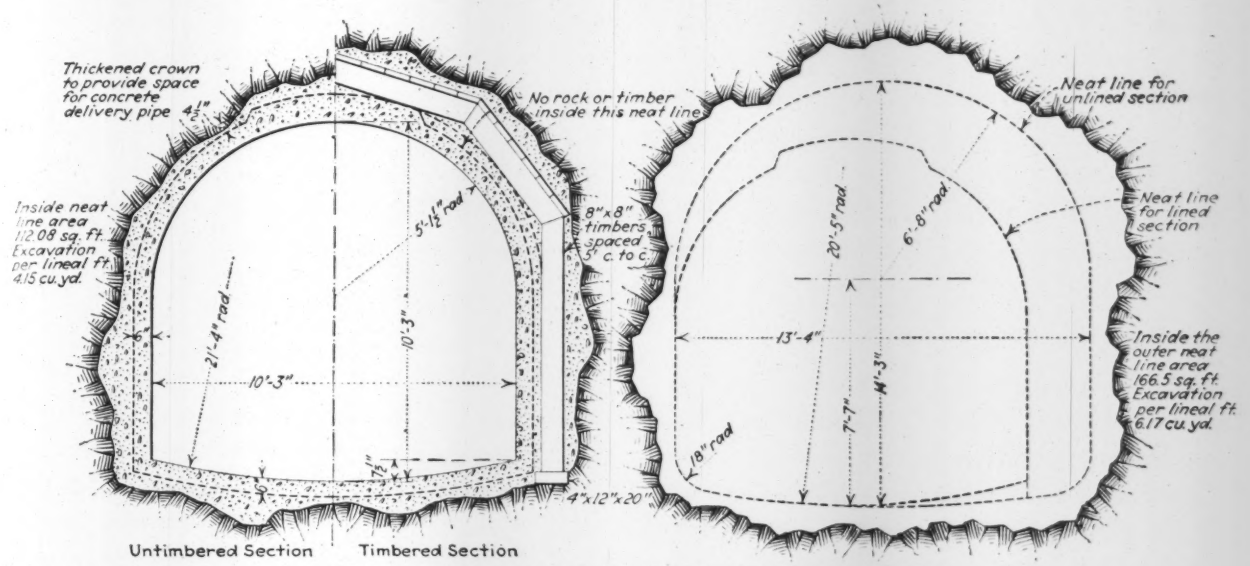

Thickened crown to provide space for concrete delivery pipe 4½"
No rock or timber inside this neat line
Neat line for unlined section
Inside neat line area 112.08 sq. ft. Excavation per lineal ft. 4.15 cu. yd.
8"x8" timbers spaced 5' c. to c.
5'-1½" rad.
2'-4" rad.
10'-3"
10'-3"
6"
13"
4"x12"x20"
20'-5" rad.
6'-8" rad.
Neat line for lined section
13'-4"
14'-3"
7'-7"
18" rad.
Inside the outer neat line area 166.5 sq. ft. Excavation per lineal ft. 6.17 cu. yd.
Untimbered Section
Timbered Section

FIG. 2—LINED AND UNLINED SECTIONS OF FOOTHILL TUNNELS

Moccasin Creek power house. Here water from the tunnels of the mountain division that has passed through the Moccasin Creek plant will be collected at the foothill division intake. The reservoir will be formed by two dams constructed about 2,500 ft. apart in the natural bed of the stream, one above the power house and the other below the foothill tunnel intake. The natural flow of Moccasin Creek will be bypassed through a reinforced concrete conduit, Fig. 4, 10 ft. in diameter, to be constructed between the two dams along the stream channel in the bottom of the reservoir. The downstream dam will be an earth- and rock-fill structure, 800 ft. long and 55 ft. high, containing 125,000 cu.yd. The reservoir capacity will be 550 acre-ft.

It is not contemplated that the conduit through this reservoir will carry the maximum possible floods from the 33-square mile drainage area above it. However, on the occasions when these extraordinary floods occur, it is planned to close the tunnel intake gate temporarily and let the flood sweep through the reservoir during the short period of excessive flow. Afterward the reservoir can be sluiced out and normal operations resumed. This is unlikely to be necessary, however, more than once in several years.

On the San Joaquin Valley pipe line no construction has yet been done, because this section cannot function before the completion of the tunnels in the Coast Range division, which will require a much longer construction period.

On tunnels of the Coast Range division preliminary work has been under way for about a year, with the result that as soon as funds are available the work can be started promptly on a large scale. The cross-section of the Coast Range tunnels will be the same as that of the foothill tunnels, but the grade is only 0.0005, which will

COST ESTIMATES ON HETCH HETCHY WORK YET TO BE DONE IN SAN JOAQUIN AND COAST RANGE DIVISIONS

San Joaquin pipe line, 47.4 miles, 60 in. or equivalent. Including appurtenances		$8,650,000
Coast Range tunnels (including lining), 28.6 miles, 10¼ ft. diameter, at $95 per foot	$14,326,190	
Five shafts, exclusive of concrete lining, 2,650 ft. at $250 per foot	662,500	
Underground cross-connections	125,000	
Concrete lining in shafts, 2,650 ft. at $50 per foot	132,500	
Special portal construction	30,000	
Alameda Creek siphon, 0.6 mile long	160,000	
Land and rights-of-way	50,000	
Deduct for allocation to Coast Range from 1925 fund	$1,542,554	
Net total of additional money for Coast Range division		13,943,636
Connections at Irvington, 1.4 miles of 60-in. pipe, including appurtenances		236,225
Administration, engineering and contingencies		1,170,139
Total		$24,000,000

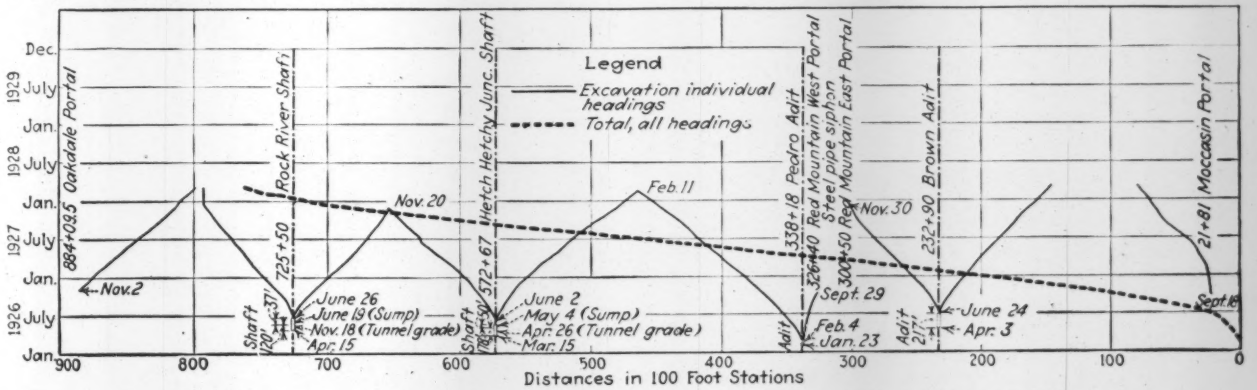


FIG. 3—CHART SHOWING INDIVIDUAL AND TOTAL HEADIN G ADVANCES, FOOTHILL TUNNELS

give a capacity of only 250 m.g.d., as compared with the 400 m.g.d. of the foothill and mountain divisions. It was not considered economical to make this tunnel smaller than 10¼ ft. and, on the other hand, this maximum capacity of 250 m.g.d. added to the 65 m.g.d. available from local sources near the city will make a total sufficient to supply San Francisco until the population exceeds 3,000,000. Under these conditions it was not economical to drive a bore large enough to carry 400 m.g.d., as the saving in interest on the cost difference between that size and the smaller section adopted will more than pay for

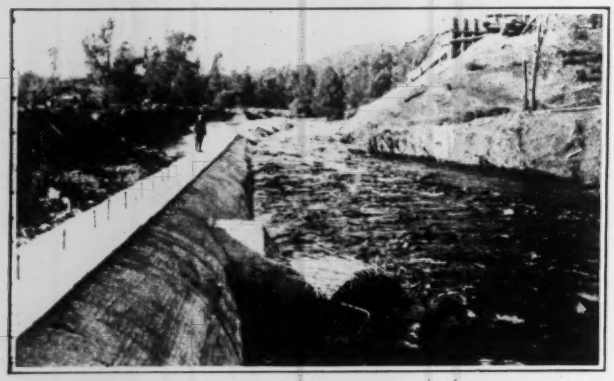


FIG. 4—CONDUIT THROUGH SITE OF MOCCASIN REGULATING RESERVOIR

Inside diameter 10 ft. The Y-connection is for drainage of the reservoir through a gate tower yet to be constructed.

a duplicate parallel tunnel that can be constructed when it is warranted by the population increase.

The Coast Range tunnels will be advanced from four portals and five shafts, or fourteen working faces. Preliminary work on the Coast Range division has included the repair of existing roads and the construction of new ones, as well as the building of five construction camps and some work on each of the five shafts. These shafts will have a total depth of 2,650 ft., of which about 900 ft. had been excavated up to March 1, 1928.

The shafts are 6¾x20 ft. in plan outside the timbering, and instead of being located over the tunnels, as has been the practice elsewhere on the project, they will be offset from the tunnel center line about 95 ft. The short section of tunnel between shaft and main bore is to serve later as part of the crosscut between the first tunnel and the parallel bore that is to follow. These crosscuts will be 3 to 5 miles apart and will be used during construction as underground space for machine shops, compressor plants, etc. When the first tunnel is completed and lined, a plug will be poured in the crosscut at the intersection, thus leaving the crosscut accessible through the shaft after the tunnel is in service.

Work on the Hetch Hetchy project is under the general direction of M. M. O'Shaughnessy, city engineer of San Francisco.

Railway Revision in India

In the construction of the big tunnel for the Great Indian Peninsula Railway, described in *Engineering News-Record*, Sept. 29, 1927, p. 502, the contractor's agent at first was J. Pollack, as stated, but it appears that after a few weeks he was succeeded by W. J. Brand, who had been in charge of the 17-mile tunnel for the Lochaber hydro-electric project in Scotland.

Sodium Aluminate for Softening Water at Hinsdale, Ill.

SUBSTITUTION of sodium aluminate for alum as a coagulant at the water-softening plant of Hinsdale, Ill., has materially reduced the hardness and alkalinity of the water, the cost of chemicals and the amount of filter wash water, according to a paper by Harvey Menold, superintendent of water-works, read at the annual meeting of the Illinois Section of the American Water Works Association.

Raw water with a hardness of 468 and an alkalinity of 375 p.p.m., pumped from a deep well, enters the bottom of two mixing tanks, to which hydrated lime and soda ash are fed by automatic proportioning dry-feed machines. Alum was formerly added here in the same way. The repumped sludge is also added and the water agitated mechanically. Under the new plan the coagulant, in the form of 34 per cent liquid sodium aluminate, is added to the water, treated otherwise as described above, as it enters a long trough, the dose being applied and regulated as to amount by a small motor-driven pump. Then the water passes to the coagulating basin, where the larger part of the solids are precipitated, and then to the settling basin, from which it flows over a weir to the carbonating basin, where carbon dioxide is added. Beyond this are the filters.

A high magnesium content makes this water difficult to soften. The consulting chemist recommended a finished water having a total hardness of 85 and a total alkalinity of 85. But lime, soda ash and alum would not react and give this quality without excess caustic alkalinity, which increased the work of the carbonator. It was therefore decided to try sodium aluminate. As this is alkaline, it permits a reduction in the soda ash charge, while giving faster reaction and better coagulation.

Formerly the water was treated with 3.15 lb. hydrated lime, 0.933 lb. soda ash and ⅛ lb. alum per 1,000 gal. (approximately 22, 6.5 and 0.88 gr. per gallon, respectively). The water from the clarifier then showed a total hardness of 157 and an alkalinity of 147, with 23 p.p.m. caustic alkalinity. When treated with 3.3 lb. hydrated lime, ¾-lb. soda ash and 0.28 lb. liquid sodium aluminate, the water showed 98 p.p.m. total hardness, 85 alkalinity and only 15 caustic alkalinity. This resulted in reductions of 4.1 per cent in cost of chemicals, 36 per cent in amount of gas for recarbonation and 64 per cent in the amount of water for backwashing the filter, the latter due to improved coagulation by the use of sodium aluminate. With alum, a scale formed on the walls of the filters and basins, but continued use of the other coagulant removed practically all of this scale.

A test is to be made with 84 per cent solid sodium aluminate in place of 34 per cent in liquid form.

Overflow From Septic Tank a Nuisance

Overflow from a septic tank to a ditch and over the land of a complainant was held to be a nuisance, and an abatement order issued by a lower court of Oklahoma. The state supreme court affirmed the decision on Jan. 24, 1928 (Town of Jennings vs. Pappenfuss, 263, p. 456). According to a brief abstract of the decision in *Public Health Reports* for March 30, 1928, the plaintiff alleged that the "odor and stench" from the overflow made it "practically impossible to live upon his farm."

Trend of Portland and Accelerated Portland Cement Composition

Gap Between Present Composition and Pure Tri-Calcic Silcate Being Closed by Manufacturing Refinements

By Edwin C. Eckel
Consulting Engineer, Washington, D. C.

IN THE first edition of "Cements, Limes and Plasters," published many years ago, I suggested that portland cement is in reality an attempt to reach the composition of the pure tri-calcic silicate—subject, of course, to necessary manufacturing limitations. The idea is now a commonplace, and I am recalling here its early statement merely to give point to what can now be proved to have actually occurred during those twenty years of slow progress. It is a proof that can be made visible, as is done in the accompanying diagram; and aside from its interest as a record of accomplished progress, it seems to me to suggest very strongly the future direction that will be taken in the development of portland and accelerated portland cement.

At the outset it may be well to define one of the terms that has just been used, since there may easily be confusion with regard to it. From my own standpoint I use the term accelerated portland, as covering a cement of

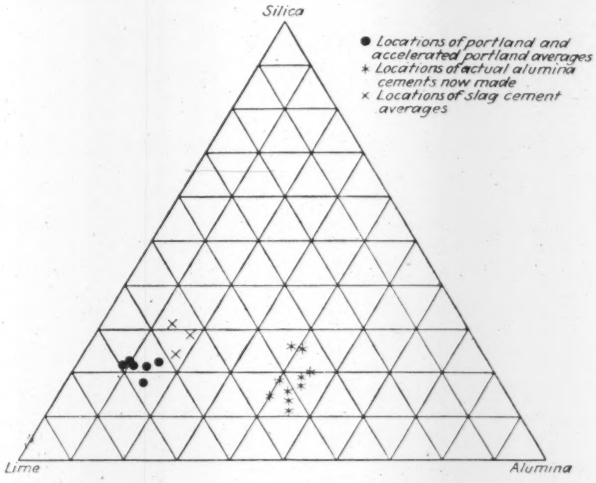

Silica
● Locations of portland and accelerated portland averages
* Locations of actual alumina cements now made
× Locations of slag cement averages
Lime
Alumina

FIG. 1—TRIAXIAL DIAGRAM SHOWING FIELDS OF PORTLAND CEMENT, ALUMINA CEMENT AND PUZZOLAN (SLAG) CEMENT. E. C. ECKEL, 1928

pure portland type which has been given new or better developed technical properties (notably high early strength) by extreme care in the selection, mixing, preparation and burning of its raw materials and in the grinding of the clinkered product, without the addition, during mixing, burning, grinding, sacking or use, of any new additional material (gypsum, of course, excepted). The accelerated portlands have come into wide use abroad, some 30 mills being engaged in their manufacture. In the United States progress along the same line seems likely to become equally a feature of the cement industry of the near future. From the engineer's standpoint we may summarize the matter by saying that in early strengths the accelerated portlands compete, to some extent, with the alumina cements. As regards chemical resistance, of course, the alumina cements have as yet no competitor.

As preliminary to consideration of the trend of portland and accelerated portland composition, it will be well to get some idea of the composition fields actually occupied by the three main types of cements now used. This has been done in Fig. 1, where the locations of actual portland, alumina and slag cements are shown by appropriate marks on a triaxial diagram. It will be seen that these fields differ considerably from those indicated as theoretically correct on diagrams that have been used by other writers; but the locations shown here correspond to the facts and are supported by some hundreds of analyses of actual cements.

The two points of interest brought out sharply by Fig. 1 are the distance separating alumina cements from the portland and slag cements; and, *per contra*, the close relationship in location between these last two types. As will be seen later, this last relationship is even now being changed, and the accelerated portlands have moved very far indeed from the neighborhood of the puzzolan field, and also still farther away from the alumina field.

With the general location of the portland composition field thus in mind, we can now profitably consider some of the details which can be shown on a larger scale, as in Fig. 2, where the extreme lower left portion of the triangle is seen.

The black circles in Fig. 2 represent the location of certain broad averages of portlands and accelerated portlands, made up from data available at different periods from 1873 to the present day. In doing this I have purposely used tabulations that were in existence before I commenced the present study, so as to eliminate the possibility, or the charge, of selecting my data to fit the conclusions. The sources of the various averages used are as follows:

A. Average of three old portlands, made between 1849 and 1873. Tabulated in first edition "Cements, Limes and Plasters," p. 575.

B. Average of 80 analyses of American portlands as made around 1905. Tabulated in first edition "Cements, Limes and Plasters," pp. 577-579. Averaged by E. C. Blanc for another purpose.

C. Average of 118 German portlands, as made around 1919. Tabulated by C. Naske; averaged by Blanc.

D. Average of thirteen recent (1926-1927) French and Belgian portlands. Tabulated by Blanc ("Le Ciment Portland," 1927); averaged by Eckel.

E. Average of five European accelerated portlands, as made 1926-27. Tabulated by Blanc; averaged by Eckel.

F. Location of one aberrant European accelerated portland. Noted in text below.

So far as concerns the five accelerated portlands whose analyses were used above *E*, it need only be said that they are all well-known and widely used European brands; all good examples of modern accelerated portlands, with nothing forced or spectacular in their properties, but capable of steadily giving compressive test results which at three days are 100 per cent and at a year still 20 per cent higher than those of the so-called "standard" portlands made at the same mill. The aberrant accelerated portland whose location is given as *F* is one of the attempts to gain speed by adding a little alumina to a regular portland mix. It is one possible way of securing an accelerated portland, but not the normal way.

When the diagram is examined in the light of these dates and other data, it can be seen immediately that the

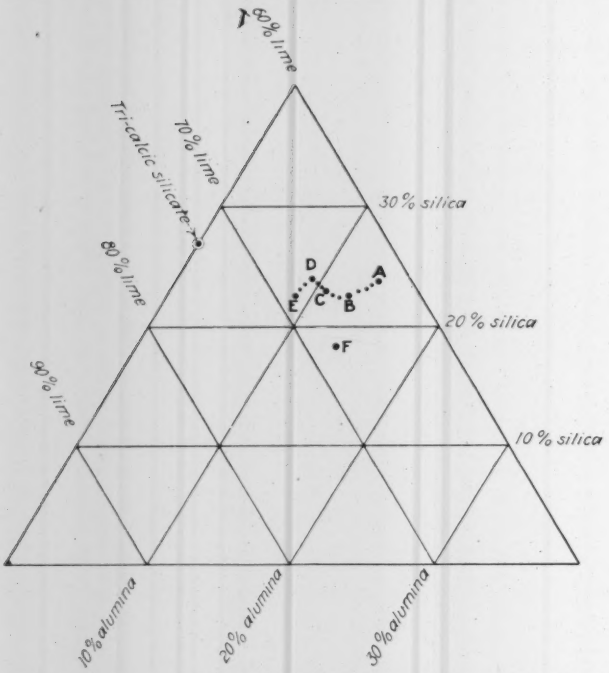


FIG. 2—LOWER LEFT PORTION OF TRIAXIAL DIAGRAM, SHOWING TREND IN COMPOSITION OF PORTLANDS AND ACCELERATED PORTLANDS FROM 1873 TO 1927

trend of portland and now of accelerated portland composition is very plainly marked. It is in the direction of tri-calcic silicate. This point, of course, it can never quite reach, but the dead space between is being gradually covered by the progress of the industry.

There are two other features which cannot be brought out in this diagram, but which suggest possible future developments of serious technical and industrial importance. Both are connected with the high lime content which the better accelerated portlands carry, as against the ordinary portlands.

The first point is that to carry this higher lime *cheaply*, the mill must have a supply of good limestone, as distinct from cement rock. The second point is that to carry this higher lime *safely*, the mill will do well to use a clay or cement rock whose silica-alumina ratio is around 3 : 1, rather than a raw material with a 2 : 1 ratio. Both of these factors will in future bear heavily against our oldest cement district, where limestone is dear and the cement rock has a very low silica ratio. Both of them, curiously enough, will bear heavily in favor of the oldest of the European cement districts, for the Tournai region of Belgium has ample limestone and a high silica ratio. The limestone requirement does not affect mills using slag as one component of a portland mixture, but the silica ratio does affect them seriously, since normal blast-furnace slags, using ordinary ore and cokes, do not give a high silica ratio.

So out of the new trend of accelerated portland development we are likely to get results of financial as well as technical importance. As for the technical results, those are already so clear in Europe that there is no need of discussing them here. The common European trade practice is to sell an accelerated portland for 25 per cent more per ton than the ordinary portland of the same mill or of the district. Since all the early strengths of the new product, up to six months at least, are more than 25 per cent in excess of portland strengths, the advantage to the engineer and contractor is obvious. He saves not only time but money by using the higher-grade cement. If, as some American mills are already doing, the accelerated portland is sold at the same price as the older product, the advantage to the user is still more obvious. No amount of conservatism in the cement industry can withstand that pressure very long.

Malleable Iron Bridge Railing Withstands Severe Tests

New Railing Material Meets All Requirements for Strength and Appearance in New Liberty Highway Bridge

By F. W. Groh

Engineer of Steel Inspection, Bureau of Tests and Specifications, Allegheny Department of Public Works, Pittsburgh, Pa.

A WIDE DEPARTURE from established practice was made in adopting malleable iron castings for the railing for the new Liberty bridge, spanning the Monongahela River in downtown Pittsburgh. This bridge connects Forbes St. and the Boulevard of the Allies on the north side of the river with the new Liberty tubes on the south side. The structure is of steel, deck truss type, 2,663 ft. long, exclusive of approaches, and rises to a height of 125 ft. above the river channel. For a bridge of this size the hand rail should be massive to be in harmony with the general appearance of the structure and at the same time should be strong enough to give adequate protection to vehicles. A rail of malleable iron castings was selected as best suited to these requirements.

This is the first use of malleable iron on bridge railing in Allegheny County and, as far as known, in this country. Fig. 1 shows the general appearance of the railing and light standards in place.

The specification requirements for the malleable iron castings were: Tensile strength, 50,000 lb. per sq.in.; elongation, 10 per cent.

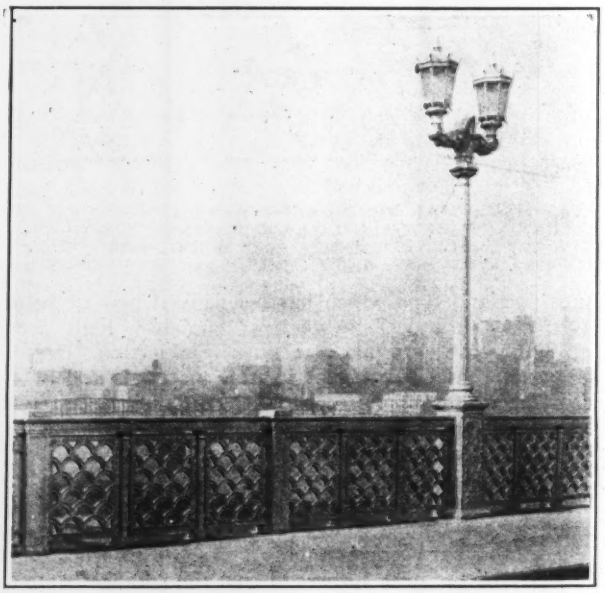


FIG. 1—MALLEABLE IRON RAILING, LIBERTY BRIDGE, PITTSBURGH

Light standards and all railing parts are malleable iron castings

The actual physical results obtained averaged:

Tensile strength	59,390 lb. per sq.in.
Yield point	38,920 lb. per sq.in.
Elongation (2 in.)	25.6 per cent
Reduction of area	25 per cent

The test bars were $\frac{5}{8}$ in. in diameter as cast and were not machined.

Impact tests were made on cast wedges, $\frac{1}{2}$x1 in. at the base and tapered to practically a knife edge in a 6-in. length. These tests were made by clamping the base of the wedge in a vise to hold it in a vertical position while a weight producing a blow of 70 ft.-lb. repeatedly was dropped upon it. This caused the wedge to curl in a scroll as shown in Fig. 2. An average of 33 blows was obtained on these wedge tests. No fracture developed in the wedges. Tension and impact tests were made on each heat used in the casting of this railing.

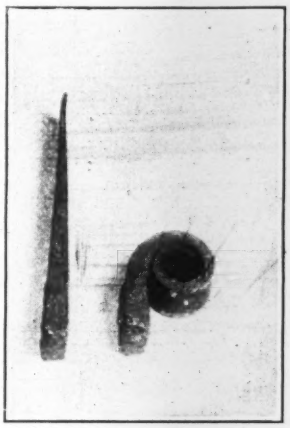


FIG. 2—IMPACT TEST BARS

Wedge shaped casting subjected to 33 blows of 70 ft.-lb. rolled up in scroll as shown without fracture.

Additional tests were made on the various members of the bridge railing to determine what impact the castings would withstand. Panel sections were subjected to testing machine impacts. Fig. 4 shows what a panel section stood without fracture. The iron posts and light standards were tested by dropping a 2,750-lb. weight on them from a height of 19 ft. None of the castings showed any signs of fracture after the impact tests.

Aside from the highly ornamental appearance that it is possible to obtain with malleable iron, its excellent physical qualities and the great impacts which casting made of it will withstand are very convincing evidence that an excellent material has been found for bridge hand railing wherever such qualities are desired.

The railing was designed by the Bureau of Architecture of the Allegheny County Department of Public Works, N. F. Brown, director. The cost of this type of railing as used on the new Liberty bridge was approximately $20 per lineal foot.

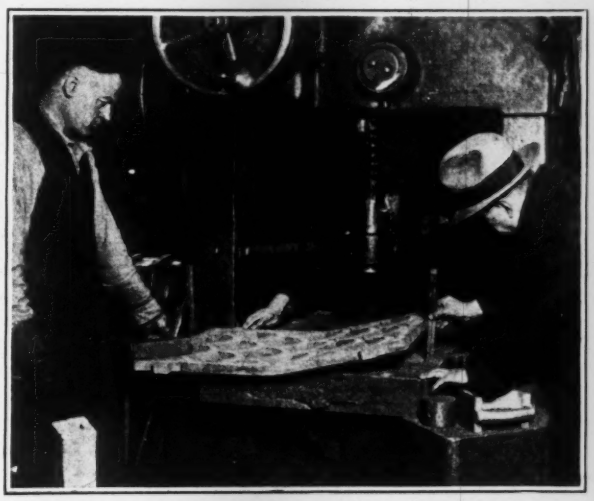


FIG. 4—PANEL SECTION AFTER IMPACT TEST

Section deflected more than 5 in. without breaking.

Castings for the above-described hand railing were manufactured by the Fort Pitt Malleable Iron Company, McKees Rocks, Pa., and the fabrication and erection were done by the Independent Bridge Company, Pittsburgh, Pa.

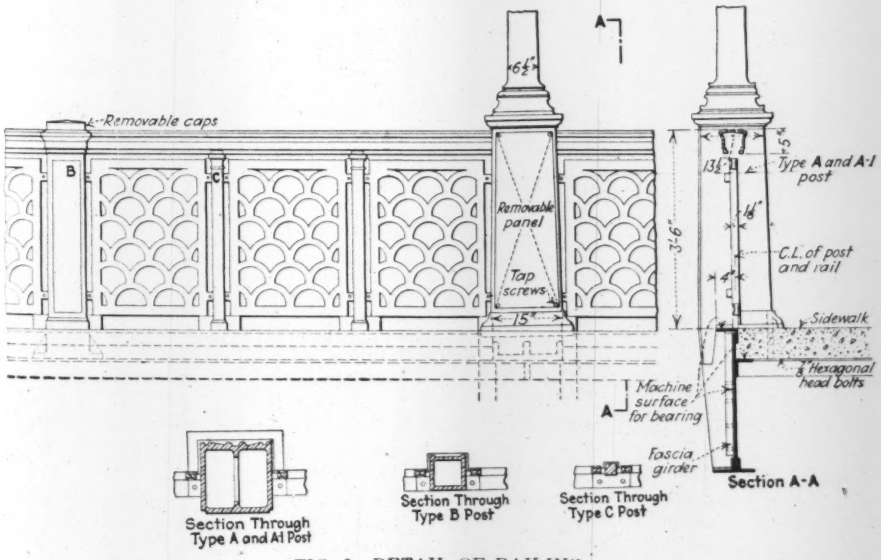


FIG. 3—DETAIL OF RAILING

May Create Sewer and Garbage Districts

The creation of public improvement districts in the five towns in Nassau County, New York, with power to build sewerage systems, sewage-pumping stations and disposal works, to build "garbage incinerators or other disposal plants and to provide for the collection of garbage and ashes," is authorized by Chapter 516 of the Laws of New York. Action to that end must be initiated by the town board, through the appointment of a "survey commission" composed of the town health officer and four residents. After the required survey has been made by the commission, sewage or garbage districts may be created, subject to the approval of the town board after public hearing. District commissioners may then be elected on petition of at least 25 per cent of the resident taxpayers of the district. These commissioners may have comprehensive plans made, issue bonds, when authorized by a meeting of district taxpayers, build works and operate them. As regards sewers, the act provides that the cost of their construction shall be borne 75 per cent by the district at large and 25 per cent by assessment on the property benefited.

Fig. 1—Mill Creek Viaduct; Kansas City, Mo.
Three spans over streets are plate girders. Sidewalk spans are I-beams

Steel Viaduct Masked as Arch Structure

Simplicity of Structural Detail Obtained Without Sacrifice of Architectural Effect—Headroom Gained by Inclosing Girders in Parapet Walls—Arches Suspended From Girders

By S. E. Berkenblit
Architectural Engineer, Chicago

REPLACEMENT of an old timber trestle at the intersection of Mill Creek Boulevard and 43d St., Kansas City, Mo., with a steel and concrete structure now known as the Mill Creek viaduct, was one of the works carried out in 1927 by the Kansas City Public Service Company. This viaduct carries the single-track Dodson line, which furnishes freight service between the southern part of the city and the Westport industrial district.

As the viaduct crosses one of the most important boulevards and thoroughfares, the city had urged the company to build a structure that would lend itself architecturally to its surroundings. The finished structure is shown in Figs. 1 and 2, and is believed to justify the effort made to obtain a design that adds to the appearance of the wide boulevard and plaza. The viaduct itself is 310 ft. long, with approach embankments having sodded slopes and landscape treatment. On the concrete work the panels were roughened by bush-hammering; the other parts were rubbed smooth with carborundum blocks.

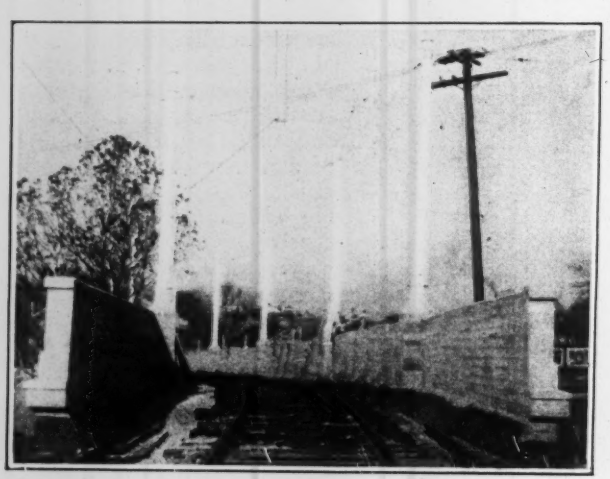


FIG. 2—THROUGH GIRDER VIADUCT
Steel girders cased in concrete. Note pedestals for trolley poles.

The track is level and on a curve of 952.5-ft. radius, with a grade of 2 per cent on the south approach. Two roadway spans and two sidewalk archways were required for Mill Creek Boulevard and one roadway span with one sidewalk span for 43d St. The boulevard is on curve and grade; 43d St. intersects it at an angle of 85 deg. 34 min. and is on a grade of about 3 per cent. A minimum headroom of 13 ft. 9 in. was required on the boulevard, to accommodate double-deck buses. On 43d St. the minimum headroom is 11 ft. 6 in.

This unusual layout, including curves, skews and grades in both track and roadways, together with the requirements for headroom, presented difficult problems in design. With the old trestle, on a grade of 0.9 per cent, the distance between top of rail and paving at the boulevard was 14.7 ft. This height was increased to 18.5 ft. by making the track grade 2 per cent on the south approach and lowering the boulevard 1.5 ft. No further increase was practicable, as an increased grade would require heavier motive power and lowering of the roadway was limited by the grades and the location of underground utilities.

To secure the most desirable design from an architectural standpoint, an arch treatment was decided upon. The controlling condition was at the boulevard intersection, with a 60-ft. width of roadway and a height of 18½ ft. from rail to pavement. After deducting for depth of ballasted track, floor and a headroom of 13 ft. 9 in., only 25 in. remained for the rise of arches. With this limited rise, a solid elastic arch to carry the loads imposed was out of the question, and a design with two arch ribs connected by a flat deck would alter the exterior appearance and complicate the construction of the concrete facing. In considering the rigid-frame type of concrete construction, it was evident that a solid section rigid frame would be the most suitable. But the skews of the structure and its continuous curve would create complex secondary stresses due to loading and temperature. Any severe cracks on the face, due to such stresses, would seriously mar the appearance.

In the design finally adopted, a two-span structure,

with center pier on Mill Creek Boulevard, consists of a concrete deck on steel beams supported by steel 76-in. through girders incased in the parapet walls. The one span over 43d St. is of similar design, but with 70-in. girders. At each end and over the sidewalks the deck slab is carried by a pair of longitudinal I-beam stringers. The intermediate sections and approaches have a concrete deck on transverse steel I-beams supported on bearing walls and abutments. The different types of construction are shown in Fig. 3. The design provides for a loading consisting of an 80-ton electric locomotive followed by a train of gondola cars of 80 tons gross weight, with an allowance of 30 per cent for impact.

Details of Design—The arched roadway spans have through plate girders carrying a floor framing of 12-in. I-beams spaced 26 in. c. to c., on which is a 6-in. reinforced-concrete slab and ballasted track. The deck slab was poured on sheet-metal domes fitted between the I-beams and left permanently in place, as shown in Fig. 4, which shows also the false arch construction.

For the false arch, a reinforced-concrete slab is suspended from the floor beams by ½-in. rods, which are hooked over the I-beam flanges and slide in holes in the flanges, thus giving support during construction and also allowing the floor beams to deflect without transmitting their deflections to the arch. This false arch is an independent unit, capable of expansion and contraction without regard to the surrounding structure. Weep holes at the springing lines drain off any moisture accumulating upon the arches. The plate girders were wrapped with steel-wire mesh to provide a bond for the concrete casing and prevent cracks from developing.

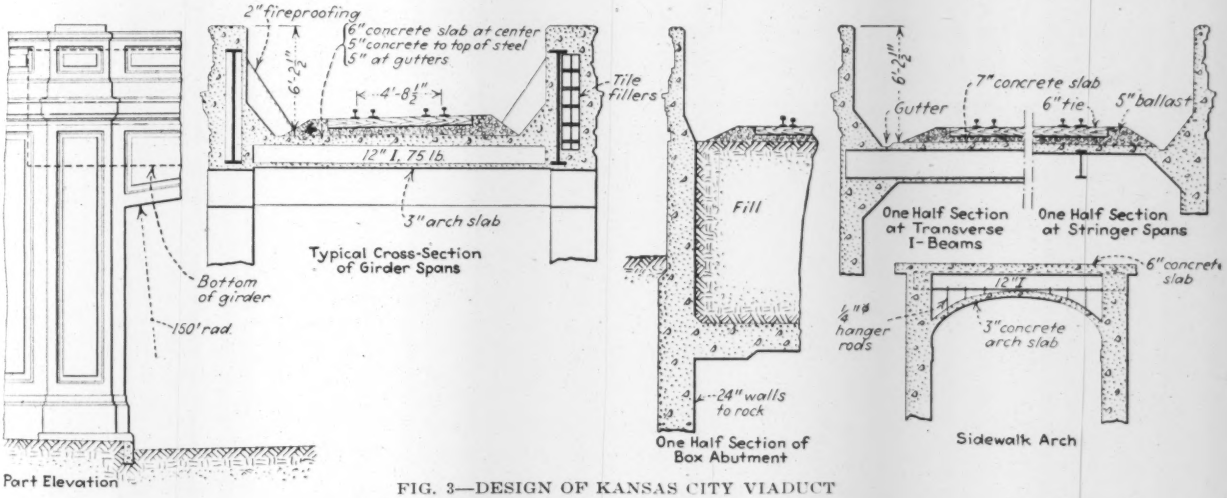


FIG. 3—DESIGN OF KANSAS CITY VIADUCT

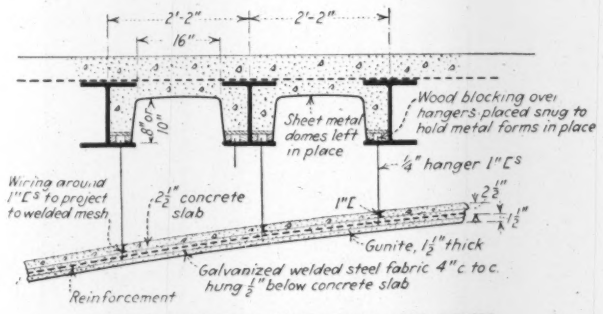


FIG. 4—DETAIL OF FLOOR AND ARCH

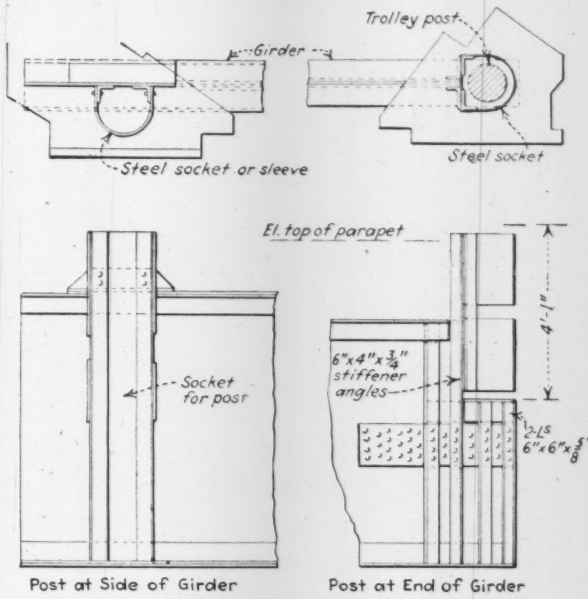


FIG. 5—STEEL SLEEVES FOR TROLLEY POSTS

On account of the curvature of the structure and to simplify the design and fabrication of steel, the plate girders are parallel over each span, and the concrete parapets fit the line of curvature. This necessitated widening the parapets at the ends and in two instances, where this width exceeded 12 in., partition tile was substituted for the concrete backing so as to reduce the dead load, as shown. On those portions of the structure between and adjacent to the roadway arches, the concrete deck is supported on I-beams resting on the bearing walls. The open spaces between the walls were fitted with steel doors or manhole frames to permit inspection of electrical work, drain pipes and catch basins.

U-shaped reinforced concrete abutments retain the earth fill and carry the track. Retaining walls of these abutments if carried to proper bearing, would have required a height of 24 ft., but to avoid such construction, a rectangular box frame was designed, open at the top and the bottom placed sufficiently below the base moldings to obtain a monolithic structure. This box rested on 24-in. plain concrete walls carried to rock and was

designed as a rigid frame. (See Fig. 3.) Borings indicated rock at about 9 ft. below grade, and the original foundation plans called for the main piers to be carried to rock and all intermediate walls to good clay soil overlying rock. In excavating, it was found that all material above rock was fill, interspersed with old timbers and débris; therefore the design was revised to carry all footings an additional depth of 5 to 8 ft. to rock. As the walls were designed for direct bearing, this alteration involved only additional concrete.

Special Features—Jackets to receive the reinforced-concrete trolley poles had to be located accurately over the centers of the pedestals and framed to the ends of the plate girders. As the girders do not follow the curve, different methods of connecting the jackets to them had to be used, as indicated by Fig. 5. These jackets consist of ⅜-in. semicircular steel plates 15 in. in diameter, bolted

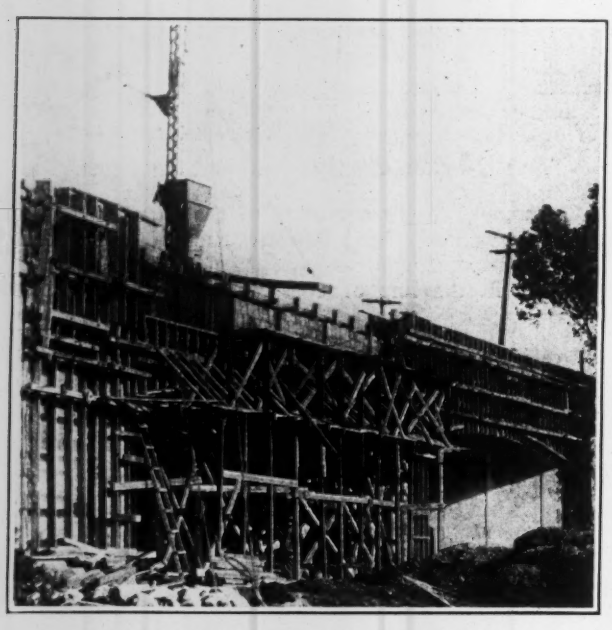


FIG. 6—CONCRETING THE STEEL SPANS

to the girder angles and of sufficient length to envelop a concrete stub 4 to 5 ft. long and 12 in. in diameter. At one pier an independent supporting frame was used, only partly connected to the girder. The poles, designed to carry a lateral pull of 2,800 lb. at the trolley connections, were grouted in the jackets. Drainage on the deck is piped to catch basins, excepting at the ends of structure, where the drains discharge on the fill.

Construction Work—To carry traffic while rebuilding the structure on the original line, a temporary trestle was built on a curve of 300-ft. radius. This served also as a work track for handling materials. The concrete plant and bins for sand and gravel were built alongside of the track. A cement storehouse north of the track had a runway underneath leading to the 1½-yd. mixer, which served a bucket on a 70-ft. steel mast from which concrete was distributed by steel chutes, as shown in Fig. 6.

Particular care was used to obtain a good puddled concrete. Concrete below grade was a 1:2½:5 mix; all other concrete was specified as 1:2:4 mix. The water-cement ratio limitations were used.

Personnel—The design and construction of this structure were under the direction of William G. Woolfolk & Company, Inc., engineers and constructors, Chicago, Ill. To insure a satisfactory appearance they co-operated with the Municipal Art Commission and E. B. Delk, architect, of Kansas City. Field work was in charge of A. E. Harvey, construction superintendent. The writer prepared all structural and architectural design drawings and details.

Car for Detecting Transverse Fissures in Rails

Electric Apparatus on Track Car Locates Internal Fissures, Marks Them on Chart and Spots Rails

RAIL DEFECTS of the transverse fissure type have become a serious problem to railway engineers in charge of track, and an important feature of the recent convention of the American Railway Engineering Association was the presentation of a special report by the committee on rail announcing the completion of a car which in traveling over the track will detect these fissures, mark them on a chart and also spot the rails with paint to indicate the location of these hidden defects. —EDITOR.

EXPERIMENTAL work in the detection of interior defects in rails with a magnetic testing device was begun by the U. S. Bureau of Standards in 1915. Later this work was enlarged upon by two railroads and a steel company, but after exhaustive tests over several years the method was discontinued as lacking practical value, since it was impossible to differentiate between the effect of slipping of drivers, gagging and cold bending of rails, accidental spike maul blows on the rail, cold-rolling effects of wheels, segregation, laminations and head breaks such as transverse fissures.

More than two years ago E. A. Sperry, of the Sperry Development Company and the inventor of many ingenious devices, conceived the idea of utilizing the air-gap resistance effect of dissociated particles or areas in the interior of rail heads to disclose their identity. His method was to force a high current at low voltage through the rail and by continuously moving a set of conductors along the rail length energize the entire rail. The resistance effect of discontinuities in the head could be detected by a pair of brushes, which would pick up this minute potential difference and transmit it to radio

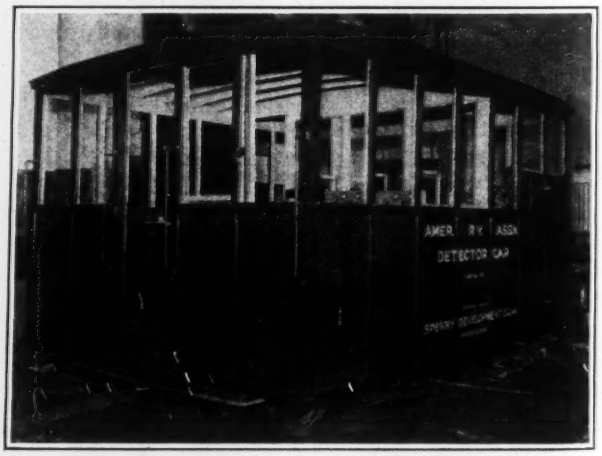


FIG. 1—RAIL-FISSURE DETECTING CAR

amplifying tubes to increase the impulse sufficiently that the needle in a galvanometer would deflect, or else to actuate pens through relays for a permanent paper record. Mr. Sperry outlined his plans to the rail committee of the American Railway Engineering Association and the association made an initial appropriation of $2,000 for a co-operative experimental study in the company's laboratory.

The apparatus proved successful, and internal breaks only 2 per cent of the head area were discovered, whereas the early expectations were that 15 per cent would be the minimum transverse separation that could be detected. It was demonstrated that unless discontinuities existed in the rail head there was no deviation of the needle of the galvanometer or movement of the recording pens, indicating that the rails were structurally sound and normal. To check this, several rail heads were fractured in short lengths under the steam hammer and were found entirely free from any indications of internal breaks or separations.

The operator became so proficient that the size and location in the cross-section of the rail head of each internal transverse fracture could be foretold very accurately. Holes drilled vertically into the top of the rail head were so accurately centered that the point of the drill met the opposing faces of the fissure within the head. These holes were drilled to introduce a fluid of the halogen group (which is possessed of extremely small molecules), expecting this fluid to penetrate freely and discolor the opposing faces of the fissure. After repeated applications of this fluid under some pressure the rail was broken at this point and not the slightest penetration could be observed, proving that the actual gap between the surfaces is sub-molecular in dimension and therefore sub-microscopic, because the little spheres representing the smaller molecules of even a halogen not only could not force their way into the crevice but could not enter it to the slightest extent, leaving the surface bright. This is the first scientific proof of the extreme minuteness of the length of the gap longitudinally in the rail.

An agreement was reached between the company and the American Railway Association in August, 1927, for the construction of a track car to be used under service conditions for the detection and marking of internal failures in rail heads. Pioneering work was required for a new device of this character, and it was not until the latter part of December that the car was ready for track tests.

The machine consists of a track maintenance car, upon which is built an inclosure containing the power plant, radio apparatus and recording mechanism. A motor car is required for towing, and the operating speed is expected to be approximately 10 m.p.h. The energizing current flows between contact brushes on the top of the rail, each contact consisting of eight individual copper brushes pressed against the rail head by springs. These brushes are mounted in a rigid frame, which is raised and lowered by a lever in the car. There are two sets of eight brushes in contact with each line of rails.

Small potential brushes mounted between the conductors form the mechanism for picking up the difference in potential from the resistance effect of the air gap at the internal break in the rail head. This microvoltage is carried to a set of four radio tubes, which step it up 200,000 to 300,000 times. A relay controls the release of a spray of paint against the side of the rail whenever a defect is found. This marking is done to aid the track men in locating defects.

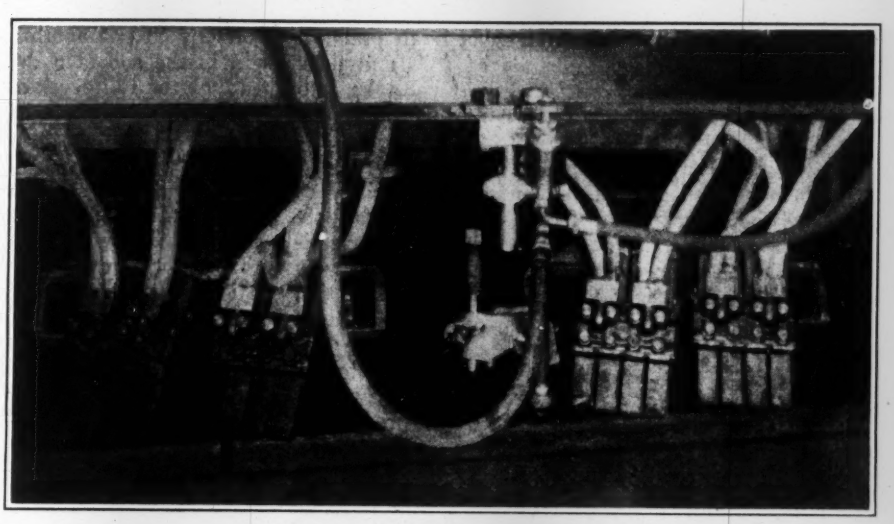


FIG. 2—CONTACT BRUSHES ON RAILS
Between two groups of main brushes is the small brush, which detects fissures. In front of this brush is the nozzle for spotting the rail with paint at each fissure.

On the recording table travels a strip of paper, in contact with which are seven pens actuated by the relays in circuit with the tubes. There are three pens for each line of rails, and the center pen records location of joints. A short transverse line is drawn by one pen if the internal break is of small area; two pens operate if the break is of intermediate size, and all three pens if it is of large area. The fissure pens are automatically thrown out of circuit when the pen for location of joints operates.

Final acceptance of the car was made contingent upon a successful and satisfactory road service test under the supervision of the committee on rail. A test track was selected on the New York Central Railroad in the yard at Beacon, N. Y., where 650 ft. of track was laid with portions of failed rails removed from service. These rails were from 8 to 22 ft. long and of various rollings from 1913 to 1925, all of the 6-in. 105-lb. Dudley section. Each rail length had developed a transverse fissure in service. All the rails were carefully tested by hand, using a portable coil and galvanometer. When the detector car was towed over this track for preliminary trials, it was found necessary to make several minor changes for more satisfactory operation. The car is now being tried on main-line high-speed track to develop the serviceability of the device and to determine the most satisfactory operating conditions.

Road Builders Require New Soil Studies

Determinations Between Adopted Moisture Limits Inadequate—Supersaturation of Frosted Soil and Colloidal Content of Soils of Vastly Greater Importance

By V. R. Burton
Engineer of Research and Statistics, Michigan State Highway Department, Lansing, Mich.

MOST of the present studies of the relation of soils to pavement structures appear aimless, so far as any practical application of results is concerned. Those who are financed by engineering organizations are expected to work along lines that will enable definite deductions to be drawn that will be of practical use to the organization. The study of soils and their relation to pavement structures, then, must take into account those factors which are known to produce the most damage and proceed straight to the goal of determined causes and probable remedies.

Soil Profile—Soil, as the term is used by soil scientists, is not a simple aggregation of organic and mineral particles, but is a vertical profile of different materials classified according to the manner in which the varying layers are arranged. According to a system of classification proposed by C. F. Marbut, of the U. S. Bureau of Soils, soil consists of the weathered zone of the original geological material, which has been altered to a greater or less extent by the weathering process, and of the parent material beneath. According to Marbut, profiles of mature soils in our climate consist of two main horizons, (1) an upper horizon of extraction called the *A* horizon, from which clay and silt have been removed by mechanical transfer, leaving it lighter in texture, and (2) a lower horizon in which the clay and silt have been concentrated, called the *B* horizon, or horizon of concentration, which is heavier in texture, because of the clay and silt concentration.

The parent soil beneath the *B* horizon is called the *C* horizon, and is the original geological material, which, in the greater part of the northern United States, means glacial drifts and sediments. These have suffered little change, except the leaching of carbonates and some other constituents. In addition to this *C* horizon it has been found necessary in engineering work to add a *D* horizon in cases in which the parent soil is directly underlain by a different type of geological material.

Consideration must be given to the entire soil profile if any adequate idea is to be had as to its effect on engineering structures which are laid in the zone of weathering. A brief description of the Waukesha silt loam found in Michigan will emphasize this. The soil consists of from 8 to 12 in. of a dark brown soil containing a high percentage of humus. Below this is from 4 to 6 in. of a brown silt loam, which coloration is derived from the humus. Below this is a compact, tight clay, yellowish brown and reddish in color, varying in depth from 7 to 18 in. Underneath this is a gravelly open substratum. Another typical Michigan soil is the Ogemaw sandy loam. From 2 to 4 in. of forest litter and humus appear on the top. Below this is an 8-in. layer of gray, coarse and medium sand. This is underlain by from 8 to 18 in. of a coffee brown, loamy, coarse sand directly over a layer of dense, heavy, plastic, pinkish to red clay. These two soil profiles are charted in the accompanying illustration.

It is, of course, true that many other soils do not exhibit such radical changes in texture; however, there are all gradations, from soils such as described above, to soils which are fairly uniform. In order to know the relative effects of the physical properties of these soil horizons on one another and on pavement that may be laid in the soil at a depth anywhere from the surface through the full depth of the weathered zone, and below, a knowledge of soil mechanics is demanded which will undoubtedly not be available for some time.

Influence of Moisture Content—In research on soils, most effort has been directed to the determination of permeability, bearing value, compressibility, etc., of soils having moisture contents that vary from an air-dry condition to that of saturation. Even though these properties were capable of exact and definite determination on all types of soils, it is doubtful if this knowledge would be of practical value to aid us in the design of pavement structures. Prof. H. M. Westergaard has shown in a paper delivered at the fifth annual meeting of the Highway Research Board in December, 1925, that a variation of subgrade reaction of 400 per cent produces a corresponding change in pavement stress of not much more than 10 per cent. The researches of L. W. Teller, of the Bureau of Public Roads, showed similar small variations in stress, with a wide variation in the character of the soil and moisture contents beneath the pavements examined. These researches are verified by the experience of most highway engineers. Little difference is experienced in pavement breakage between the moisture content extremes of saturation and dryness after drouth, except in the case of certain highly colloidal soils.

The situation is entirely different during the late winter and in the early spring when the ground is frozen, and when, in popular parlance, "the frost is coming out of the ground." Considerable damage is done during the winter to pavement surfaces on account of the disruptive action of the frost in heaving up the pavement. As the frozen soil thaws, the situation is still more serious. There are then long stretches of road beneath the surface of which the soil is completely liquefied, with a moisture content far above normal saturation. Practically all of the serious pavement breakage in states within the frost area is caused by this oversaturation of soil during freezing. An investigation of this phenomenon is of far greater importance than the investigation of the bearing power of soils between an extreme of dry soil after a drouth and its subsequent saturation. That this oversaturation of soil takes place while the soil is still frozen can be easily demonstrated.

Research carried on by the Michigan State Highway Department during the winter of 1926-27 showed that the maximum expansibility of a saturated soil of any type would not amount to much more than slightly over 4 per cent by volume. If we assumed 5 ft. of frost in the ground, which is greatly in excess of anything which we have in Michigan, except in the extreme north, and if

we assumed all of this expansion to be vertical, we could account for only about 2.4 in. of heaving. It is a matter of common knowledge that frost heaves are far in excess of this amount. Even if we assumed the space beneath the pavement to be filled with pure water, we could account for only 5.1 in. of heaving, provided we have 60 in. of frost and all of the volumetric expansion were vertical. Frost heaves of 6 in. are extremely common and many differences in elevation of a foot or more have been noticed. The only explanation that can be had of this phenomenon is that the actual volume of water beneath the pavement at the point of heaving has been increased by addition and not simply by expansion, and addition while the soil was frozen.

All engaged in highway work in the frost area have noted that after the frost goes out of the ground in heavy soils in many cases the subgrade is a semi-liquid containing an amount of water that it could not possibly have held in the unfrozen state and losing it immediately drainage is effected. Research in capacity of a soil to absorb water must then be carried to much greater percentages of water than have hitherto been considered necessary, probably to the limit of segregation of the coarser particles, beyond which limit the soil loses its identity as such.

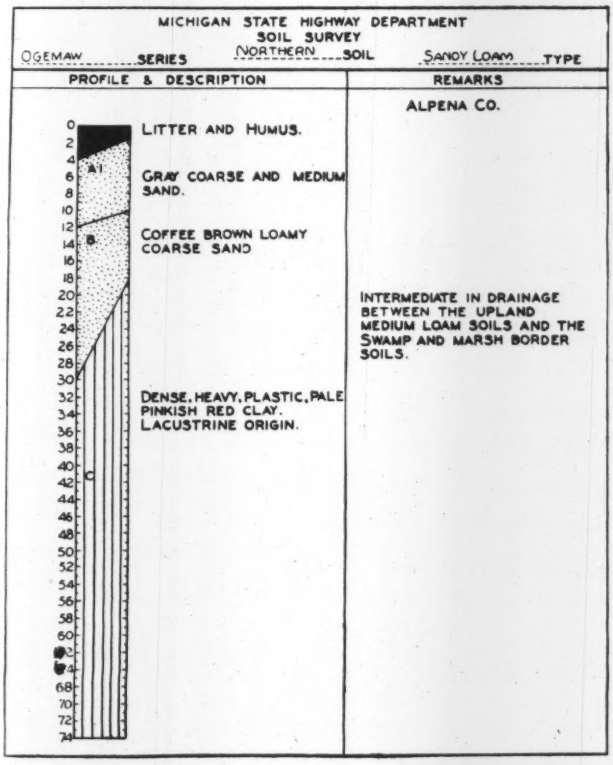
A study of the phenomena similar to that mentioned in this article will be of much more practical value to the highway engineer than anything at present being done in the field of soil research. For this study the Michigan State Highway Department, in co-operation with the University of Michigan, Department of Civil Engineering, is building a cold room in which temperatures as low as 0 deg. F. can be reached and in which temperatures can be varied at will.

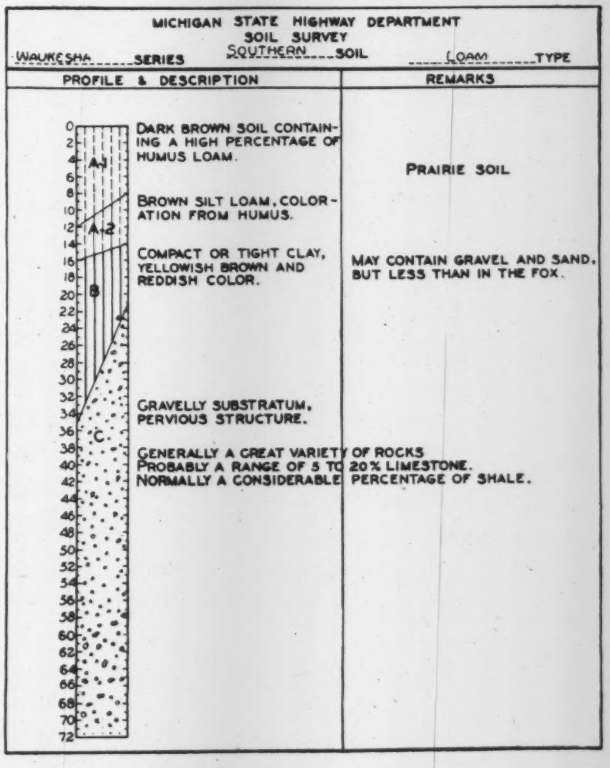
It has been stated that permeability, bearing value tests, etc., are largely for purposes of identification of the soil. It appears to the writer that there is no particular point to an identification that depends upon properties that are of comparatively small value, even though they are accurately obtained. A description of the soil constituents and their mode of occurrence is much more to the point for purpose of identification, and if any routine physical tests are to be added to the means of identification, they should be of some actual value in a description of properties that are pertinent to the problem.

Influence of Colloids—The early physicists assumed that the soil was an aggregate of mineral particles the properties of which were dependent on their size, shape and gradation. This view is no longer held by a large number of modern soil physicists. Some sands may be practically a simple arrangement of mineral particles, but clay structure is due not only to the mineral particles but to a colloidal content that has an extremely important bearing on the soil characteristics. Some physicists go as far as to say that this fraction of the soil is the one part of it that absolutely determines its physical properties. Any theory of soil mechanics that does not take into account the existence of this colloid fraction is fundamentally wrong, and it is not surprising that a good many difficulties have arisen in attempts to explain certain soil phenomena on a purely structural basis.

This colloid fraction is far from being an insignificant one either in amount or in effect. The amount varies from 3 to 5 per cent in certain sands, up to as high as 70 per cent in clays, and in some peats runs well over 90 per cent.

The following soil phenomena are directly dependent on the amount and activity of the colloids: Attraction for water or its hygroscopic content, adhesion, heat of wetting, freezing point depression, unfree water, vapor


MICHIGAN STATE HIGHWAY DEPARTMENT
SOIL SURVEY
OGEMAW SERIES NORTHERN SOIL SANDY LOAM TYPE
PROFILE & DESCRIPTION
REMARKS
ALPENA CO.
A1
LITTER AND HUMUS.
GRAY COARSE AND MEDIUM SAND.
B
COFFEE BROWN LOAMY COARSE SAND
INTERMEDIATE IN DRAINAGE BETWEEN THE UPLAND MEDIUM LOAM SOILS AND THE SWAMP AND MARSH BORDER SOILS.
C
DENSE, HEAVY, PLASTIC, PALE PINKISH RED CLAY. LACUSTRINE ORIGIN.


MICHIGAN STATE HIGHWAY DEPARTMENT
SOIL SURVEY
WAUKESHA SERIES SOUTHERN SOIL LOAM TYPE
PROFILE & DESCRIPTION
REMARKS
A1
DARK BROWN SOIL CONTAINING A HIGH PERCENTAGE OF HUMUS LOAM.
PRAIRIE SOIL
A2
BROWN SILT LOAM, COLORATION FROM HUMUS.
B
COMPACT OR TIGHT CLAY, YELLOWISH BROWN AND REDDISH COLOR.
MAY CONTAIN GRAVEL AND SAND, BUT LESS THAN IN THE FOX.
C
GRAVELLY SUBSTRATUM, PERVIOUS STRUCTURE.
GENERALLY A GREAT VARIETY OF ROCKS PROBABLY A RANGE OF 5 TO 20% LIMESTONE. NORMALLY A CONSIDERABLE PERCENTAGE OF SHALE.

PROFILES OF TYPICAL MICHIGAN SOILS

pressure, evaporation, water-holding capacity, capillary movement, percolation, plasticity, soil structure, shrinkage, etc. It would be just as reasonable to neglect the study of cement in concrete as to neglect the study of this colloidal material which serves as the cementing material in soils; with this difference, that in numerous soils the colloidal content is enormously higher than the content of cement in any concrete mixture made.

Mention of some recent research by soil physicists may be of some interest. Cameron, Gallagher, and especially Keen, have shown that evaporation is mainly controlled by colloids—that this is true can easily be demonstrated by measuring the rate of evaporation before and after the destruction of the colloids by ignition. Boyoucos has shown that permeability is affected by the gel portion of the colloids.

That capillary rise is not a function solely of grain size or shape has been demonstrated by a number of soil scientists by the use of organic liquids, such as ligroin, benzol, kerosene, etc., as a liquid medium in the investigation of capillary rise in clay. These liquids will rise three or four times higher in a clay during the first couple of days than does water, in spite of the fact that their surface tension is much lower than that of water. The reason for the decreased rise of water has been explained by the swelling of the gel of the colloid, which constricts the passages and prevents its rise. Water will eventually rise higher than the organic liquids, due partly to the greater attraction and adsorption that colloids have for water and partly to the ability of the fine particles and colloids to support a higher column of liquid, due to their greater number of interstitial angles. If, however, a non-colloidal material, such as fine quartz sand, is used, water will rise faster and higher in this quartz sand than will the organic liquids, showing that this phenomenon is purely capillary.

Recently in the soil laboratory at Ann Arbor it was decided to check up the influence of surface tension and capillarity on the shrinkage of clay soil. Three other organic liquids were used in the comparison with shrinkage produced by water. The surface tension of these organic liquids was about one-third that of the water, but it was thought that some shrinkage values might be obtained by the standard shrinkage tests, using these organic liquids with the dry soil. With the water a percentage of shrinkage of 25.8 per cent was obtained. A shrinkage of 13.3 per cent was obtained with alcohol, but with ligroin and carbon tetrachloride, possessing respectively a surface tension of about 20 and 29 dynes per centimeter, it was impossible to get any shrinkage at all. On attempting to remove the disk of soil from the dish, the material broke up like a friable sand, showing that there was practically no force acting to hold the clay particles together. It is therefore quite apparent that capillary pressure alone by no means serves to explain the shrinkage of clay soils.

Proposed Soil Tests—The present standard physical tests of soil being used by a number of engineering laboratories are in need of considerable revision if the results are expected to be used in an investigation of pavement subgrade. It is proposed to use the following tests in our own soil laboratory:

1. Mechanical analysis: This will not only report the screen material, silt and so-called clay but also the percentage of colloidal material in the sample.

2. The activity of this colloidal material as exhibited by its adsorption of water vapor will be reported.

3. The moisture equivalent of the soil will be retained until more satisfactory method of indicating moisture capacity of the soil is developed.

4. The slaking value of the soil will be retained, inasmuch as it is felt that this is an index of the manner in which shoulders and slopes of excavated material will wash or slide under the action of moisture. The slaking value test as conducted at present is, however, unsatisfactory, and some other procedure than the former standard should be used. This test deserves considerable study.

5. The amount of organic material in the soil should be reported, especially when dealing with high colloidal materials such as peats and mucks.

6. Some method should be devised that will give an indication of the ability of the soil to promote moisture transfer during a frozen condition. It is considered probable that this is intimately associated with its colloidal content and character, and all phases of the matter should be thoroughly studied.

It should be understood that the writer is not depreciating the importance of bearing value and permeability tests when applied to foundation work. The problem for the pavement engineer, however, is fundamentally different, due to the fact that all pavement structures in the climate of northern United States are subject to the action of frost, and this action, due both to the expansive force of the material itself and to subsequent oversaturation of the soil, is by far the most important question with which we have to deal. Soil conditions are so variable in the weathered zone, both vertically and horizontally, that physical tests cannot be directly applied to the design of pavement. Investigation of certain phenomena having to do with moisture content may help us to understand what is going on in the soil and may also suggest a remedy.

Pavement Surveys—The problem of correlation of soils with pavement structures, then, resolves itself largely into a statistical one. A certain design of pavement and underdrainage on a certain soil, under a given traffic, of a certain age, etc., will show a satisfactory condition as found by survey. Other designs are not found suitable and should not be used, or the same effect may be secured by varying the factors depth of pavement, underdrainage and reinforcing, etc. Soil conditions vary from slab to slab, and each slab must therefore be studied separately. Due to the large number of factors involved, in order to get sufficient examples for comparison, large mileages must be chosen. This is a tremendous task, but due to modern methods of sorting and tabulating data, the job is not a hopeless one by any means. As a matter of fact, in about a year's time it will have been accomplished on 1,600 miles of highway in Michigan.

Unfortunately, soils are regional in character and classification, due to the varying geologic, climatic and topographical conditions that produce them. The studies made in Michigan will be of little value to any but adjoining states, and a nation-wide survey is a colossal undertaking to contemplate. The detailed study necessary to make the results of definite value will have to be made by the locality directly interested on a scale that few have yet had the temerity to attempt. There is, however, no question whatever as to its value, as even from the incomplete studies possible in Michigan to date several necessary and radical changes in design have been made.

Expansion Joints in Wilson Dam Sealed by Asphalt Grouting

Seasonal Leakage in Inspection Tunnel Under High Head Checked by Unusual Method of Placing Hot Asphalt

By Hans Passburg
Scotia, N. Y.

As the pool elevation above Wilson dam was raised during the fall of 1924, it was noticed in the inspection tunnel that water was leaking through some of the 115 vertical expansion and construction joints in the spillway and power house sections of dam. A leaking joint is shown in Fig. 3. Tar paper was installed in all expansion joints during construction of the dam, but owing to contraction being concentrated at a few places instead of being uniform at all joints, gaps at many places were too large to be effectively sealed by this means. During the following winter leakage, which had stopped at nearly all places during the summer and was greatly reduced at all other places, increased as the expansion joints opened due to the contraction of the dam, and it appeared possible that this cycle of leaking joints would occur during a part of each year unless a seal strip of elastic material which would accommodate itself to expansion and contraction, could be introduced in the joints.

The inspection tunnel is 6 ft. wide and 9 ft. high, with the bottom 90 ft. below pool level and 20 ft. below extreme tail water level. The average head on the tunnel

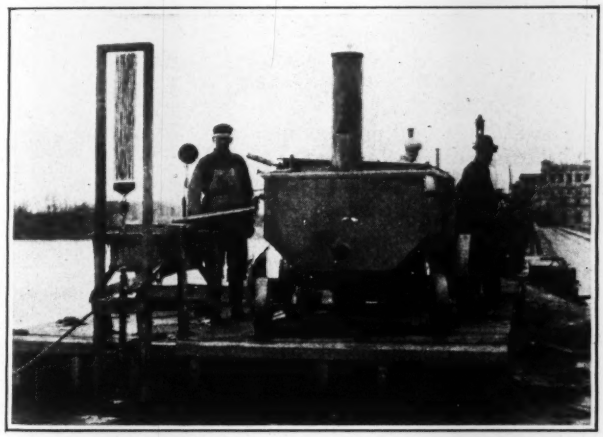


FIG. 1—ASPHALT GROUTING EQUIPMENT

is 86 ft., corresponding to a hydrostatic pressure of 37 lb. per sq.in. Water entered from both side walls, as well as from the top and bottom of the tunnel.

The opinion was expressed that the expansion joints would become tighter in time, but considering the 90-ft. head at the bottom of the tunnel and the fact that some of the joints are certain to open during each winter, it was decided to find some way of sealing them and so abate a possible seasonal nuisance. Other factors affecting the decision were the expenditure that would be necessary in keeping the tunnel unwatered and the desirability of having easy access at all times to the piping and the spillway gate operating valves, located in the bottom of the tunnel.

Consideration was first given to the possibility of stopping leaks from the inside by means of cast-iron linings and cement grout forced in under air pressure between the lining and the tunnel walls. This scheme, however, was abandoned because of its cost.

Finally it was decided to put well drill holes down in the expansion joint plane and fill them with asphalt. Three experimental 5-in. holes, 125 ft. deep, were drilled in the power house section. Asphalt was precast in plugs 2 ft. 2 in. long and the plugs were dropped into the holes. Due to the fact that asphalt was a little lighter than water when hot and but a little heavier when cold, the plugs would not go down without being forced. When force was applied, the plug was deformed, closing the hole entirely, thereby preventing the water in the bottom of

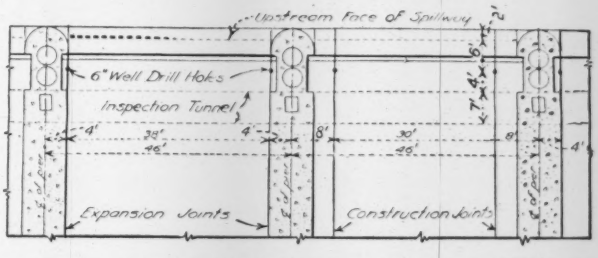


FIG. 2—SECTION OF DAM SHOWING LOCATION OF WELL DRILL HOLES

the hole from escaping. One of the joints was sealed by this method, but due to its uncertainty the scheme was abandoned.

The only known method left of getting asphalt in holes was the method developed by George W. Christians, of Chattanooga. Consequently on Sept. 29, 1926, an agreement by contract was entered into between the district engineer and Mr. Christians, the latter to seal the expansion joints by the asphalt grouting method. With this method hot asphalt is pumped at any desired pressure through a pipe, in the center of which is an iron wire, insulated from the pipe and heated by electric current. The hot asphalt is delivered to the point desired and by means of pressure applied by a pump is forced into cavities, completely filling them. Mr. Christians has used this method successfully at Hales Bar dam on the Tennessee River, in grouting foundations, and at Dix River dam, Kentucky, in stopping leakage around the abutments.

During the latter part of 1926, 115 well drill holes 6 in. in diameter were put down, one on each expansion joint in the spillway as well as the power house section of dam. These holes were drilled 4 ft. upstream from the upstream face of the inspection tunnel, as shown in Fig. 2. In cases where the expansion joint stopped at tunnel floor elevation, drilling of holes was stopped there; elsewhere the holes were carried 3 ft. into the rock foundation. The maximum and the minimum depths of holes were 138 and 73 ft. respectively.

A 6-in. hole is somewhat larger than necessary for asphalt grouting. The larger diameter of hole, however, practically eliminated any chance of missing the expansion joint plane at the lower levels by deflection of the hole, and further it provided a larger reservoir for the asphalt sealing material.

In checking the vertical alignment of holes the plumbing method was used. In addition to this check, nine holes were drilled in the tunnel wall to the necessary depth to meet the well drill holes. The nine holes were selected from the results of plumbing. Six of these were

considered as doubtful, two considered as good and one considered to be badly out of alignment.

In drilling into the face of the tunnel wall well drill holes were met at approximately the right depth, with only one exception, when the well drill hole had moved upstream 13 in. but was still in the expansion-joint plane. With regard to alignment parallel to the inspection tunnel, the jack drilling proved in eight out of nine cases to coincide with the well drill holes.

Work on asphalt grouting was started Dec. 17, 1926. For filling the holes with asphalt, standard black iron 1½-in. pipe was used. The pipe was cut in lengths of about 6 ft. 9 in. and assembled with standard couplings. The bottom end of the length which was lowered to the bottom of the drill hole was flattened for a distance of 3 in. and drilled for a ½-in. machine bolt. In addition, two slots about 8 in. long were cut in the lower end of the pipe to allow the asphalt to flow out. For centering the pipe in the hole, ¾-in. bent rods were welded to each third length of pipe.

The heating element consisted of a No. 6 iron wire, connected to the lower end of the pipe by means of the machine bolt and carried up through the center of the pipe. Great care was taken in preventing the wire from making contact with the pipe, except at the bottom. Small insulators of special design were inserted in each pipe coupling for this purpose. Only one-third of the pipe area was occupied by the insulator, thus allowing sufficient room for the passage of the asphalt. At the top end of the pipe an insulating stuffing box was attached. This stuffing box allowed the resistance wire to be extended vertically above the pipe. By means of an insulator the wire was connected to door springs 1 in. by 14 in. long, suspended from a wooden frame, as shown on Fig. 1. These springs were stretched in attaching the wire so that slack in the wire, caused by heating, would be taken up by the tension of the springs, thus preventing a short circuit and the eventual burning off of the wire.

FIG. 3—AN EXPANSION JOINT IN THE INSPECTION TUNNEL
Above, before sealing with asphalt. Below, after the sealing had been completed.

The electric circuit through wire and pipe was completed through a group of six 220/11-volt transformers, high-voltage sides connected in parallel to a 220-volt feeder and low-voltage sides connected in series, thus making available voltages from 11 to 66. Maximum current was 120 amperes.

The kettle, asphalt pump and connection to the grouting pipe are also shown in Fig. 1. The pump was a 1-in. boiler test pump, fitted in an open-top steel box of about 6-cu.ft. capacity.

Filling a hole was accomplished by pumping hot asphalt through the pipe to the bottom of the hole, which in all cases was full of water up to the pool elevation. Leaving the bottom of the pipe, the asphalt made contact with the water, which cooled its upper surface, causing it to congeal and form a semi-plug of varying thicknesses. The hole was then slowly pumped full, using the heated resistance wire only enough to maintain a fluid passage through the pipe. The cold asphalt plug was thus forced slowly to the top of the hole, lifting out the water as it rose. As soon as the plug formed, pressure began to build up. This pressure increased and decreased according to the hardness and thickness of the plug, and was regulated by increasing or decreasing the current in the resistance wire or by changing the temperature of the asphalt in the kettle. The temperature range was from 350 to 450 deg. F.

The average pumping pressure was 150 lb. per sq.in. and the time required to fill one hole was about six hours.

After filling a hole with asphalt, the resistance wire was cut off 2 ft. above the crest of the dam, coiled up in the hole and then covered with a hard grade of asphalt (220-240 F. Oxide Asphalt).

For grouting the first 22 holes, or all those in the power house section, a grade of asphalt designated as 30-40 penetration was used; for the spillway section a slightly softer grade was used, designated as 40-50 penetration. A total of 154,000 lb. of asphalt was used in grouting the 115 holes, which had a total depth of 11,081 ft.

Results—Before grouting, no leaks were detected at 51 of the 115 joints, while of the remaining 64 joints 25 were leaking badly. After grouting with asphalt the water stopped leaking through 30 joints, of which twelve had been leaking badly; seventeen others, four of which had leaked badly, were practically stopped—that is, within 95 per cent; fourteen joints, eight of which had leaked badly, were partly stopped; and at three joints grouting failed to decrease the leakage.

It is believed by the contractor that the minor leakage after grouting was due to horizontal joints between lifts of concrete and occasional diagonal cracks which permitted water to pass around the asphalt plug in the expansion joint.

Attempts were made to measure the total amount of water coming through the joints before and after grouting, but no accurate figure could be obtained. It might

be stated, however, that the leakages on Dec. 12, 1926, in the power house section of the tunnel raised the water level in the tunnel 1.2 ft. in one hour. This corresponds to a leakage through the 22 expansion joints of almost 3 sec.-ft. The leakage after the completion of the asphalt grouting in this section was negligible.

With regard to the spillway section, the measurements were problematic, inasmuch as the increase in the water level was caused not only by leakages through the expansion joints but also by leaking water pipes.

Cost of Work—The cost of drilling and grouting (including material, labor and royalty paid contractor) was:

COST OF ASPHALT GROUTING PER FOOT OF HOLE

	Drilling	Grouting
Spillway section	$2.48	$2.46
Power house section	$2.29	$2.99

As indicated, the results of the asphalt grouting were very successful, inasmuch as the leakage has been greatly restricted. If in the future it should be desired to cut down the leakage further, this could readily be done by uncovering the grouting pipe and resistance wire, connecting these to the grouting equipment and forcing more asphalt into the joint.

It appears that the asphalt grouting is the most satisfactory and also the most economical method for sealing joints between the blocks of a dam. At Wilson dam, 6-in. holes had to be drilled, the cost of which amounted to 48 per cent of the total cost.

The work was carried out under the direction of Lieut. Col. M. C. Tyler and Capt. Hugh P. Oram, district engineers, U. S. Army, at Florence, Ala., with the approval of Major General Edgar Jadwin, Chief of Engineers.

Brick Research in Bureau of Standards

At the recent convention of the Common Brick Manufacturers Association, George K. Burgess, director, Bureau of Standards, in a paper on "Industrial Research" outlined the work that the bureau is doing on common brick. According to Mr. Burgess, such matters as the quality of brick, the component materials and the properties of brick, such as strength, color, resistance to heat, sound transmission, and porosity, are involved in much ignorance. To better this condition the ceramic division of the bureau with the help of an advisory committee representing the industry is studying some of these problems. Principally of interest to the manufacturers of brick are the bureau's current studies on the drying of clay, on several types of extrusion machines and augers and on the qualities of different clays and shales. With regard to the use of brick in building work, the bureau has completed its study of fire resistance.

Other studies under way include the examination of (1) factors governing transmission of moisture through brick walls, (2) factors governing adhesion of mortar to brick, (3) the acoustical properties of partition walls and (4) heat transmission qualities. Subjects for future study include the following: (1) Relation of the physical properties of brick and its absorption to its ability to resist freezing, (2) ability of walls to withstand lateral forces caused by wind and earthquakes (in which one of the most important factors is mortar adhesion), (3) the stiffening effect that brick walls afford to a building frame of steel or concrete, (4) the efficiency and possible field for reinforced brickwork and (5) the characteristics of different types of mason's mortars.

Bearing Capacity of Soil

A Restatement of the Basis for Rules as to Bearing Capacity of Cohesionless and Cohesive Materials

By Charles Terzaghi
Associate Professor of Foundation Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

THE article on "Rules for Foundations on Yielding Soils Found Unsatisfactory" (March 29, p. 520), by R. H. Chambers, gives me welcome opportunity to emphasize some points concerning foundations which, for the sake of brevity, I failed to bring out in sufficient detail in my paper read on the same subject before the American Society of Civil Engineers, published in *Proceedings*, November, 1927.

These points essentially concern the origin of the rules concerning the ultimate bearing capacity of perfectly cohesionless and very cohesive materials, respectively. It obviously was my fault if my statements produced the impression that the rules were derived from the few test results quoted in my paper. The rules are derived not from the tests but from three independent groups of theories having in common no more than the accepted fundamental equation known as Coulomb's equation, $t = c + p \tan \phi$, wherein t is the tangential resistance of the soil against sliding along any interface, c is the cohesion per unit of area and ϕ is the angle of internal friction.

Of the three theories, one is based on the theory of the equilibrium along cylindrical sliding planes (see Krey, "Erddruck und Erdwiderstand," third edition, Berlin, 1926); the second one on the general theory of flow in plastic bodies (L. Prandtl, "Ueber die Härte plastischer Körper," *Proceedings* of the K. Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-physikalische Klasse, 1920); the third one on Boussinesq's equation (Terzaghi, "Erdbaumechanik," Wien, 1925). None of the quoted books and papers has thus far been translated into English. However, an application of the first theory to certain stability problems will appear within a short time in *Public Roads*, the publication of the U. S. Bureau of Public Roads.

There is a certain variation between the numerical values furnished by the different theories. However, those general conclusions which conform with all the theories deserve as serious consideration as any law of applied mechanics. If experience should apparently be at variance with these conclusions, it would merely mean that our conceptions concerning the values of c and ϕ are still inadequate and that our methods of determining these coefficients need a revision; but very few who are familiar with the theories will doubt the validity of the conclusions as such. Two of these conclusions are:

1. The ultimate bearing capacity of perfectly cohesionless materials per unit of area increases in direct proportion with the width of the loaded area, provided the loaded areas are similar in shape. If ultimate failure (rapid sinking at constant load) on an area of width b starts at a settlement s_1 at a load q per unit of area, the failure due to loading an area n times wider would start at a settlement somewhat in excess of ns_1 at a load nq per unit of area. On the settlement produced by loading different areas with *equal* loads per unit of surface the size of the area will have little effect. This conclusion comprises both of my statements quoted by Mr. Cham-

bers on pp. 520 and 521. When speaking of a contradiction between these statements, Mr. Chambers obviously failed to realize the great difference between "bearing capacity" (load required to produce failure) and "settlement under equal unit loads."

2. The ultimate bearing capacity (per unit of area) of soils with marked cohesion is independent of the size of the loaded area, provided the shapes of the areas are similar and provided the weight of the soil located between the loaded area and a depth equal to the smallest width of the loaded area is small compared with the load required to produce failure. If failure caused by loading an area of width (or diameter) b starts at a settlement s_1 under a unit load q, the failure on an area n times wider will start at exactly the same unit load q, but at a settlement ns_1. The settlement produced by loading different areas with *equal* unit loads will increase in direct proportion with the width of the areas.

The conditions that existed at the site of the Nebraska State Capitol strictly agree with the requirements for the second conclusion. Of this conclusion it was claimed that it is as valid as any of the laws of applied mechanics; and, from his knowledge of the subject, the writer would say it is more accurately true than the rules that are used for computing the stresses in concrete construction. Yet the ultimate bearing capacity at the site of the Nebraska State Capitol was, according to Mr. Chambers, 63.2 tons per sq.ft. for an area of 1 sq.ft. and 94.4 tons per sq.ft. for an area of 4 sq.ft., instead of being exactly equal as required by the afore-mentioned law.

There can be no doubt about the accuracy of the tests, but there are very serious doubts concerning the uniformity of the loaded material. The Dakota sandstone is nothing but a sand cemented together by a natural process. Considering the universal lack of uniformity of the compressibility of natural sand deposits and, in addition, the well-known differences between the compressive strength of concrete specimens made of identical raw materials, a difference of 50 per cent between two loading tests performed on the Dakota sandstone on *equal* areas would have been by no means surprising. Perfect uniformity of a sandstone deposit cannot be taken for granted, and since the degree of uniformity was not investigated the test results cannot be considered as a valid argument.

The other data cited by Mr. Chambers are also by far too fragmentary and incomplete to carry any weight against rules derived from the accepted laws of applied mechanics. The systematic tests made on areas up to 9 sq.ft. for checking Conclusion 2 have thus far confirmed its validity.

There is, in addition, one set of confirming data that came to the attention of the writer quite recently and that was obtained under soil conditions very similar to those existing in Nebraska. Loading tests were performed on a soft, friable limestone (sandstone consisting of calcareous materials). The results were as follows:

Loaded Area	Settlement in Inches Under 4 Tons Per Sq.Ft. Observed	Computed From (c)
(a) 1 ft. square = 1 sq.ft.	0.4	0.6
(b) 1.41 ft. square = 2 sq.ft.	0.6	0.85
(c) 10 ft. square = 100 sq.ft. (finished building)	6	6

Another conclusion furnished by theory under conditions which seem to establish its validity beyond any doubt concerns the importance of the effect of the ratio $t \div d$ (depth of foundation divided by the width of the loaded area) on the ultimate bearing capacity of perfectly cohesionless materials. Tests made on a small scale on a perfectly cohesionless sand deposited under identical conditions for the purpose of checking the theoretical results furnished the following figures:

Value of $t \div d$ =	0.0,	0.5,	1.0,	1.5
Ultimate bearing capacity per unit of area, q =	1 ,	2.1,	3.9,	6.2

The numerical values furnished by different theories concerning the influence of $t \div d$ on q are somewhat different, but the importance of that influence can no longer be questioned.

The observation which Mr. Chambers quotes as demonstrating the compacting effect of pile driving on the clay affords an interesting example of the arching that takes place within the clay between the piles. To appreciate this arching effect it is sufficient to remember that the length of the piles is many times greater than the spacing. Suppose we investigate the consistency of a clay by driving a sounding rod into it. Then we fill a pipe with a very much softer clay and drive the sounding rod into the content of this pipe. We shall certainly discover that the sounding rod will get stuck in the soft clay at a much less depth than it did in the unconfined but stiffer clay, because any displacement of the clay from within the pipe requires the overcoming of the adhesion acting along the surface of contact between the pipe and the clay. On the other hand, when pulling the rod out of the pipe, the resistance of the pipe prevents the clay which surrounds the rod from slightly expanding, a friction-reducing phenomenon that always occurs when pulling a pipe out of an unconfined clay deposit.

In a comparison of the compactness of two materials (in our case the clay before and after the pile driving), the first and fundamental requirement consists in testing the materials under practically identical test conditions. The arguments presented by Mr. Chambers fail to satisfy this fundamental condition.

The writer wishes to thank Mr. Chambers for bringing some more data to the attention of the profession. He fully agrees with him concerning the urgent need of full-sized tests. At the same time he wants to emphasize the importance of the theoretical side of the subject, because, without well-founded theoretical conceptions to start with, the full-sized tests will lead nowhere. The history of modern engineering is essentially the history of tests guided by theory.

Preliminary Survey of San Francisco Harbor

The Chief of Engineers has forwarded to the Secretary of War a report on the "Preliminary Examination and Survey of the Harbor of San Francisco, California," recommending modification of the existing project so as to provide for a main channel across the outer bar 45 ft. deep at mean lower low water and 2,000 ft. wide; the removal of Presidio Shoal, Rincon Reef (Inner), Rincon Reef (Outer), Blossom Rock, and Alcatraz Shoal westward of a north and south line 2,000 ft. west of Alcatraz Light to a depth of 40 ft. at mean lower low water; the removal of Arch Rock, Shag Rocks Nos. 1 and 2 and Harding Rock to a depth of 35 ft. at mean lower low water; and the removal of Raccoon Shoal and Point Knox Shoal westward of a north and south line through Point Stuart Light to a depth of 35 ft. at mean lower low water, at a total cost of $1,284,000, with $200,000 annually for maintenance.

Concreting the Toltec Dam, Zuni Mts., New Mexico

A Study in Designing Mixes With Harsh Aggregates—Hot Water and Torch Give 85-Deg. Concrete With Frozen Aggregates—Grouting With Converted Cement Gun

By A. F. Schramm
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A Significant Experience in designing workable concrete mixes, using harsh aggregates and the standard curves developed for the water-cement ratio method, is related in this article. The conclusions merit attention. Besides the difficulties in securing a designed mix, the method of placing concrete in winter at an elevation of 8,000 ft. calls for special consideration. Briefly, using water heated to 200 deg. and a torch in the mixer and using cold aggregates, concrete was put into the forms, through several hundred feet of open chute, at a temperature of 85 deg. Foundation grouting presented an interesting detail in the use of a converted cement gun for high-pressure injection. —Editor.

ACCURATE control of concrete mixtures using angular aggregates and placing these mixtures under extreme frost conditions were major construction problems in building the Bluewater Toltec

FIG. 1—ARCH DAM AT 8,000-FT. ELEVATION, ZUNI MOUNTAINS, NEW MEXICO
Stores 55,000 acre-ft. of snow water for the Bluewater Toltec Irrigation District in New Mexico.

Irrigation District dam in the Zuni Mountains of New Mexico in 1926-27. The dam is a concrete arch, Fig. 1, of usual section, with a gravity-section concrete abutment at one end. It is 78 ft. high above stream bed and 500 ft. long on the crest. The location is in a deep box-canyon of sandstone formation capped with limestone. Incidentally, a water-bearing stratum of this sandstone in the foundation introduced an interesting grouting problem. As located, the dam will impound snow water from above the 8,000-ft. elevation, the reservoir having a capacity of 55,000 acre-ft.

Concrete Design—It was originally intended to use a volumetric mix of 1 : 2½ : 5 proportions. A change was made to a mixture designed by the water-cement ratio method. The aggregates were limestone crushed to 2 in., crusher screenings, screenings from sand rolls and river sand, which was available for a part of the work. The local limestone was dry and dense, but with wide variations in hardness and absorption. It crushed irregularly, with many elongated, flattened particles and with 17 per cent screenings through ¼ in. The screenings showed the same physical characteristics as the coarser crushed material. The river sand was excellent in quality and gradation. Analyzed more precisely the average aggregate characteristics were:

Coarse Aggregates: Fineness modulus, 8.12; gradation, poor; deficient in smaller sizes; many long flat pieces; absorption 4 to 15 per cent, and very rapid for ten minutes.

Screenings: Fineness modulus, 3.57; gradation, poor; many long flat particles; 20 per cent passing 100 mesh; absorption very rapid and constant at 6 per cent.

River Sand: Fineness modulus, 3.63; gradation, excellent; passing 100 mesh, 15 to 20 per cent unwashed and 7 to 11 per cent washed; little clay or silt shown by colorimetric test.

In mortar tests unwashed sand showed 20 per cent higher strength than washed sand, and screenings with dust 15 per cent higher strength than screenings with the dust removed. The microscope showed both sand and screenings dust to be true rock particles.

The design problem, then, was to produce a workable, dense, easy-chuting concrete testing 1,700 lb. in 28 days, keeping cement at a minimum, with no inundation; with sharp stone and screenings having little slipability and high and varying absorption, and with river sand having 8 per cent moisture; and with the necessity, due to limited storage space, of using sand alone, screenings alone or a combination of sand and screenings. Using the charts and curves of the Portland Cement Association, numerous mixtures were tried out and the following working mixes determined: Sand 85 per cent and screenings 15 per cent, 1 : 4.95 : 4.36; all sand, 1 : 4.85 : 5; all screenings, 1 : 4 : 4.3; all mixes predicated on 7 per cent absorption in limestone and 8 per cent moisture in sand.

A cold spell in December froze up the river-sand beds, and sand rolls were installed. The mix was changed to 1 : 4.15 : 4.15 and later to 1 : 4 : 3.75. Diatomaceous earth was used in one day's run in an endeavor to secure better workability and strength; the results were unsatisfactory in both respects. It was found that 15 per cent fine river sand added to the screenings would greatly increase workability. Sand was therefore trucked 11 miles to provide this percentage.

Two troublesome factors were found in operation. The varying and continuous absorption of the rock and a long chute line often caused drying out in the chutes. Also the different moisture and absorption of the various fines, necessitating abrupt changes in volumes of mixing water, gave trouble at the mixer. No special controls were provided on the mixer. Two inspectors were used, one at the mixer, the other at the point of placement. Telephone communication was available and a series of signals by whistles was established. Instructions were to

err on the side of increased strength, control being at the discretion of the chief inspector and largely exercised by varying the amount of aggregate, keeping the water at the desired volume. Careful education of the mixer gang and the co-operation of the contractor soon eliminated much of this trouble.

Concrete was placed by chuting. Quarry, crusher, mixer and other plant were on the bluff 200 ft. above the stream bed. A 21S mixer was used. The mixing time was set at 1½ minutes and it was rigidly adhered to. Frequent checks were made on the aggregates and the mix was modified as necessary. In all cases the fines were from 48 to 55 per cent of the total aggregate. Adequate sprinkling prevented any checking. Much of the dam was rubble concrete, but a check on straight proportions was kept. The total volume of concrete was 14,000 cu.yd.

The conclusions drawn from these tests and from the actual use of sharp and interlocking aggregates are: (1) The curves and charts (water-cement ratio method) as now given are not strictly applicable; (2) workability is

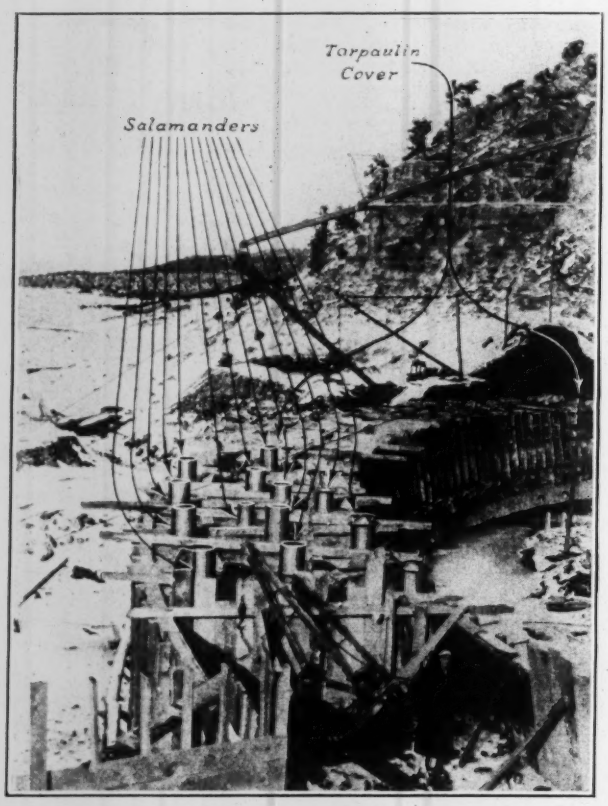


FIG. 2—TOLTEC DAM UNDER CONSTRUCTION IN WINTER
Note the arrangement of salamanders and tarpaulin covers, in spite of which the top surface froze a few inches deep.

a factor of the mortar content of the mix; (3) oversanding 5 to 10 per cent is very desirable both for workability and for density; (4) the use of 15 per cent of fine rock particles passing a 100-mesh screen increased workability, density and imperviousness without loss of strength; (5) adding 15 per cent of river sand to screenings improved chuting and placing qualities.

Winter Concreting—Concrete placing was continuous during the winter except for a period in late December and early January. Placing was begun early in October and frost came nightly within a few weeks, the high altitude accentuating the daily variation, as shown by the following temperature tabulation:

Dates	Degrees Fahrenheit Daytime Maximum	Night Maximum
Nov. 1 to 10	50 to 60	22 to 28
11 to 15	30 to 45	4 to 10
16 to 30	33 to 50	18 to 25
Dec. 1 to 15	25 to 40	15 to 22
16 to 23	5 to 15	0 to —26
24 to 31	.....	No concreting —4 to —18
Jan. 1 to 12	.....	No concreting 0 to 18

As indicated by the tabulation, the men were laid off for the holidays and concreting was not resumed until late in January, when the temperatures were similar to those of November. All concrete was poured in the daytime with the temperatures of the chutes at or above freezing, until the cold snap in December. The aggregates were not heated. The dry rock did not freeze; the sand was often frozen. The lowest observed temperature of aggregates when introduced into the mixer was 6 deg. above zero.

Hot Water and Torch—The mixing water was heated to 200 deg. by waste steam. A free-flame gasoline torch was installed on the mixer frame above and to one side of the hopper chute, the nozzle just outside the drum with the flame directed against the rising side of the drum and through the falling concrete. The torch was simple, being a large pressure tank and a flexible feed line with a preheating nozzle equipped with air vents. The control was on the tank. A large, intensely hot blue flame could be developed. With aggregates above 20 deg. no flame was used. Below this the torch was kept turned on constantly through the mixing period.

The general procedure was as follows: In starting, the torch was turned on full, with the drum full of hot water. When the water reached the boiling point, it was dumped down the chute line and a batch was put in the mixer. The usual mixing time was used and the temperature of the concrete was taken in the chute hopper; if from 90 to 105 deg., the usual time was used on the next batch; if hotter, the torch was cut down; if colder, the mixing time was increased. The temperature was read at the point of placement, and after the chutes had thoroughly warmed up, the torch and mixing time were regulated to give 85 deg. at the point of placement. The temperature added by the torch was not determined, but only in the cold snap in December was it necessary to increase the mixing time. From five to ten batches were necessary to establish control. Instructions were to keep below 115 deg. at the mixer and above 85 deg. at the forms for the first few batches to provide plenty of heat against the cold concrete and forms. Necessary changes were directed from the point of placement and were made by the mixer man without taking temperature readings at the mixer. In no case did the temperature in the chute hopper exceed 115 deg. No flash setting resulted, and all strength tests were good.

The chute line varied from 400 to 600 ft. in length, with heat losses from 10 to 25 deg. in the line. In the thin, dry air, variations in wind velocities and direction gave widely different losses. Cloudy days were difficult problems. No consistent check of chute losses was made, the control being at the vital point.

Heavy forms of 4-in. plank lined with No. 18 sheet iron were used. Tarpaulins were spread over the top of the fresh concrete, but no attempt was made to protect the sides. This was ample protection until the sudden drop on Dec. 15. The pours, 4½ ft. thick and from

12 to 16 ft. wide, developed great heat. With the sudden drop in temperature, salamanders were placed under the tarpaulins, but they proved inadequate. The concrete froze a few inches deep on top but not on the sides. In a test on Dec. 26, air temperature —18 deg., concrete four days old subjected to nightly temperature of —18 to —26 deg. and daytime temperatures of 5 to —18 deg. protected only by tarpaulins, gave 28 deg. 2 in. down and 34 deg. at a depth of 4 in. The contractor ceased work during the extreme cold and on resumption it was found that thawing and resetting made little chipping necessary.

Cylinders were made daily and tested for 7 and 28 days' strength; 97 per cent of the tests were within 10 per cent of the estimated strength, the remainder being very erratic. All concrete weighed from 150 to 152 lb. per cubic foot.

Grouting Foundation—Examination of the sandstone formation of the dam site disclosed numerous faults, but owing to the remnants of two former earth dams, with their accumulated talus and riprap, these faults could not be followed and test borings were unreliable.

Excavation was started in the center, and the bedrock was found to be scaly and badly seamed. Grout holes disclosed a thin water-bearing stratum at an average depth of 5 ft., beneath which was a heavy layer of dense quartzite. The top 12 to 18 in. of the bedrock was shot off; grout holes were drilled 8 ft. deep on 5-ft. centers, and the entire area was grouted. Additional holes were used until all evidences of water were cut off. A 5-ft. key, carried down 2 ft. into the quartzite, was dry, proving the efficiency of the grouting.

The grouting methods were unusual. A standard cement gun, air at 150 lb. and water at 200 lb. pressure were available on the job. The makers of the cement gun advised that successful grouting had been done with the standard equipment by using excess water at the nozzle and 80 to 90 lb. air pressure. Sand was dried and carefully screened through a No. 14 mesh and all possible combinations of this method were tried without success under the conditions. Disconnecting the water hose and adding water in the mixing chamber was also tried, with poor results.

The successful procedure was found by entirely disconnecting the water line and removing the nozzle, mixing the grout to a thin consistency in a separate vat; placing it in the gun and shooting it with 100 to 150 lb. air pressure. It was soon demonstrated that thorough and continuous mixing of the grout was essential, so the entire amount of grout deemed necessary for the hole was thoroughly mixed for five minutes before using. Two men stirred constantly during grouting, which was almost continuous, only 45 seconds being required to load the gun.

At first sections of 1-in. pipe were cemented into the holes and the hose was connected directly to them. Later the pipe was omitted and a 2-ft. section of pipe was attached to the hose. Various materials were used for packing between the pipe and the holes, but strips of cement sacks, built up in a taper and wired in place, were found most effective. The hose man twisted this pipe, with its attached packing, into the hole and held it there during grouting. By this method the hose was quickly placed or removed and leakage was held to a minimum. Thorough blowing out of the gun and the use of plenty of wash water after each set of holes prevented any clogging. The success of this method was due to the efforts of the contractor's superintendent and crew. The crew consisted of one foreman, acting as a gunman, one hoseman and two men mixing grout. The foreman was white and the others were Navajo Indians at $2.50 a day.

The writer was resident engineer in charge of construction. V. L. Sullivan, of El Paso, Tex., was consulting engineer and Anderson Brothers, also of El Paso, were the contractors, with Frank Wadlington as superintendent.

British Consider Means of Standardizing Engineering Practice

At a meeting recently held in London to consider means for the further development of standardization and simplification the President of the British Board of Trade, Sir Philip Cunliffe-Lister, stated that a resolution was passed at the Imperial Conference in 1926 in favor of the further development of standardization in the widest sense of the term. Inquiries have since been proceeding to give effect to the resolution in Britain. The movement has received further impetus from the visit of Mr. Julius, the chairman of the Australian Council for Scientific and Industrial Research and of the Commonwealth Engineering Standards Association, who explained the steps taken to establish an Australian Association of Simplified Practice and urged the desirability of international consultation. Sir Philip said that before Britain is in a position to participate effectively in such a movement further progress must be made in Britain itself. For this reason he called the meeting in London to ascertain the views of some of the representative British associations.

With regard to standardization proper, Sir Philip said that it was most desirable that the valuable work of the British Engineering Standards Association should be continued and developed by that body. Attention has, however, been drawn—largely by the work done in America and Germany—to the great economies that may be effected in many trades by what is known as simplification or the elimination of unnecessary types of articles, to the consequent advantage of producers, distributors and users. This is work that must in detail be performed by those actually concerned in the particular industry in question, as manufacturers, dealers or users. At the same time the experience of other countries confirms the view that some central organization is necessary to bring before particular industries the advantages of simplification and to assist those concerned in coming together for practical discussions.

Sir Philip therefore asked the meeting to consider the desirability of establishing a central committee to undertake this work. He did not think it could be done effectively by a government department, but said that what was needed was a representative body in close touch with the various branches of industry.

The subsequent discussion showed general agreement as to the importance of developing standardization and simplification farther than the movement has yet gone and as to the necessity of having some central organization of the kind suggested. The meeting requested that a representative of the Board of Trade should act as a chairman of the proposed body. It was accordingly decided to set up a committee under the chairmanship of Herbert Williams, M.P., consisting in the first instance of the representatives of the associations enumerated, together with representatives of the government departments concerned.

Engineering Literature

A Monthly Review of Books and a Listing of New Publications

To Prevent Economic Depressions

REVIEWED BY EDWARD J. MEHREN
Vice-President, McGraw-Hill Publishing Company, Inc., New York City

THE ROAD TO PLENTY: A Publication of the Pollak Foundation for Economic Research—By William Trufant Foster and Waddill Catchings. Cloth; 6x8 in.; pp. 232. Boston: Houghton, Mifflin Co. $2.

In "The Road to Plenty," Foster and Catchings offer their solution for the "dilemma of thrift" which they pointed out and thoroughly discussed in their three previous books, "Money," "Profits" and "Business Without a Buyer." These three books were written for economists; the new one for the layman, for everyone concerned with the maintenance of unbroken economic progress but without the desire to explore all the technical minutiæ of the present economic system.

The theory which Foster and Catchings have propounded in their earlier works is this: Economic depressions, with their accompanying unemployment, idle factories and capital, etc., are due to the reduction in consumer purchasing power, and this reduced purchasing power is due, in turn, to the abstraction of both corporation and individual savings from the cycle of money flow between producer and consumer. This, then, is the dilemma that the worker — who is also consumer — is urged to save, but by his savings brings about depression. He saves to his own ultimate disadvantage.

The cure for this condition, the authors believe, lies in increasing the construction of public works and production facilities at just a sufficient rate to make up for the loss due to the abstraction of savings. Thus, by putting money into the hands of workers, the purchasing power always is kept even with productive capacity. The significance of their proposal appears from the following considerations: We know that in the initial period of a great construction boom, involving both new public works and new factory facilities, the country is prosperous. The workers get money at a faster rate than the capacity of the factories to supply the goods they are able to buy. After a time the new factory facilities get into production and increase the total volume of salable goods; meanwhile, facilities being caught up, factory expansion falls off. So does worker income and consuming capacity. The result is depression. The workers cannot absorb all the goods produced; factories shut down, men are out of work and consume their savings; capital and capital investment are idle. After a while the supply of goods is drawn down, the country grows up to the larger capacity, factory wheels begin moving, purchasing power starts to increase.

Obviously, if productive capacity, instead of being increased by spurts, were developed only at the same rate as the increase in consuming power, the economic swings would be avoided. The proposal of Foster and Catchings is that a mechanism be set up for holding productive and consumptive capacity in balance, or, to put it in another way, to keep the consumptive power always large enough to absorb the goods the factories are able to produce. Their proposal, specifically, is this: That the federal government collect data that will disclose at any time the relationship between productive and consumptive capacities and, when the latter tends to decline, to increase public-works construction. Such expanded construction will act as a balance wheel in itself and will encourage industry to start an expansion program. Obviously, the data now available are not sufficient to indicate when trouble is brewing. Now we know where we are only when the depression is upon us. To serve a preventive purpose the data will need to be much expanded, and this is what Foster and Catchings recommend.

Looking at their proposed remedy, it is patent that the problem is a complex one and that the solution will not be easy. There is the difficulty, first, of getting all the data; second, of knowing what the data mean; third, of setting up the mechanism for wise and speedy increase of public-works construction. But, as the authors maintain, we should not go on hopelessly and helplessly, shrugging our shoulders and saying, "It cannot be helped." The problem is made by humans. Humans should try to solve it. We shall stumble and halt and make mistakes, but we shall not progress toward a solution unless we try.

The proposal to use public-works construction to absorb available labor in time of depression has been made at various times—by the President's Unemployment Conference during the 1921 depression, for example—and a bill authorizing such use of federal construction work is now before Congress.

The book is well worth reading. In fact, the reviewer suggests that it is a course in economics that is "easy to take" and from which every engineer and industrialist will get profit. In making the book easy to read the authors have made it wordy, but that defect can well be pardoned in view of the value of the content.

For Sanitary Inspectors

THE PRINCIPLES OF SANITATION: A Practical Handbook for Public Health Workers—By C. H. Kibbey, M.Am.P.H.A., Director of Sanitation, Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., Fairfield Utilities Co., Fairfield, Ala. Philadelphia: F. A. Davis Co. Cloth; 6x9 in.; pp. 354; 34 illustrations, including 5 color plates. $3.50.

Judging from its preface and foreword rather than its title and sub-title, this book is designed primarily for sanitary inspectors who enter upon their work without education or experience to fit them for it. Although most of the book is written in plain non-technical language, much of its contents seems unsuited for such a class of sanitary inspectors, partly because beyond the scope of their work and partly because it is too sketchy to give a correct understanding of the principles and practices outlined. This is certainly true of the sections on water supply and sewerage, particularly water and sewage treatment. We are pleased to add that in so far as the book deals with the usual work of a sanitary inspector it seems to rest on the latest principles of sanitation and public health.

A surprising and misleading feature of the book is the citation of typhoid statistics for American and foreign countries dating back many years, to the discredit of

American cities, with no hint of the great reduction in typhoid in America since then. These figures are followed by Birmingham, Ala., typhoid statistics down to 1926, showing a great decline in recent years, but not pointing out that the Birmingham rate is still far above that of other American cities of its size and larger—though lower than for some other Southern cities. The typhoid decline at Birmingham is attributed to the employment of a full-time health officer, but no hint as to what he did to cause the decline is given for the benefit of the readers of the book.

German Book on Concrete Pavements

REVIEWED BY HAROLD M. LEWIS
Executive Engineer, Regional Plan of New York and Its Environs

BETONSTRASSEN—Bearbeitet von Prof. Dr.-Ing. A. Kleinlogel, Privatdozent an der Technischen Hochschule Darmstadt. Part IV of Der Neuzeitliche Strassenbau, Herausgegeben von Dr.-Ing. e.h. Hentrich, Oberbaurat a. D. Halle, Germany: Wilhelm Knapp. Paper or bound; 6x9 in.; pp. 154; 175 line cuts and halftones. Price in Germany, 8.6 reichmarks in paper or 10.5 in cloth.

A book on concrete pavements by Dr. A. Kleinlogel is Part IV of a series of seven volumes dealing with street construction, edited by Dr.-Ing. Hentrich, of Düsseldorf. The book deals very thoroughly with not only the details of concrete pavement construction but also the problems of location, alignment, preparation of subgrade and methods of maintenance and repairs. It is freely illustrated and very readable. It should prove useful as a practical handbook for the guidance of both the designing and the construction engineer. It was prepared on the assumption that Germany is about to begin an era of intensive concrete highway construction comparable to that which has already taken place in the United States.

Much of the material is based on design and construction methods as adopted by the various state highway departments in this country. After discussing the various steps leading up to the actual placing of the concrete pavement, considerable space is devoted to a description of the various methods of curing, and of the materials, tools and methods used in repairs.

The results of maintenance tests made by a German highway construction association on various types of pavement at Braunschweig are summarized. These extended over a period of about 14½ months and covered twelve types of paving. Concrete ranked next to the lowest when used only by rubber-tired vehicles and lowest for mixed traffic, including vehicles with iron-bound wheels. In the first case the cost was 14 pfg. per sq.m. (about 3c. per sq.yd.) and in the second case 32 pfg. per sq.m. (about 7c. per sq.yd.).

The volume closes with a list of the major German concrete highway projects undertaken since 1925 and some general specifications for both construction and maintenance.

The preceding volumes of this series dealt with the more general phases of highway planning and construction, and with the various types of stone pavements. The final three volumes will deal with the various tar and oil penetration methods of paving, asphalt pavements and highway administration, respectively.

A recent German book, by Prof. E. Neumann, dealing in a more general way with all types of highway construction, was reviewed by the present writer in these columns March 15, 1928, p. 453.

An Outline of Federal-State Aid

FEDERAL AID: A Study of the American Subsidy System—By Arthur F. Macdonald, Ph.D., Assistant Professor of Political Science, University of Pennsylvania. New York: Thomas Y. Crowell Co. Cloth; 6x9 in.; pp. 285. $2.75.

Increase in federal aid from $8,000,000 in 1912 to $147,000,000 in 1925 and a decline to only $137,000,000 for 1927, notwithstanding the pleadings for reduction to the vanishing point by President Coolidge and men of lesser note, would afford sufficient reason for a book on federal aid. The fact that $81,000,000, or nearly 60 per cent of the 1927 grants, was for highways indicates that the subject has a special interest for engineers. The author believes that federal aid is fully justified, although some reforms in its administration are needed, and he believes it is destined to continue. He bases his conclusions largely upon extensive field studies, but the book contains very little that is concrete as to those studies. This does not detract from the value of the information given, although it raises a question as to the justification of the field work, the time and cost of which, so far as the book shows, might far better have been put on a study of the fundamental reasons for and against federal aid, which are treated slightly and inadequately.

Aside from its introductory and closing chapters the book is devoted to specific objects of federal aid, of which the seven principal ones, in chronological order, are: Forest fire prevention, agricultural extension, highways, the National Guard, vocational education, vocational rehabilitation and hygiene of maternity and infancy. Nothing is said of federal-state co-operation in topographical mapping and in stream gaging through the U. S. Geological Survey nor of federal aid to flood control in the Mississippi Valley. No mention is made of the vast total outlay of the United States on river and harbor work or of federal highway improvement. Nothing is said of the huge land grants for the trans-Mississippi railways. If the omissions noted are not instances of federal aid—which the author fails to define—they nevertheless form a background and might be used as a support for the federal aid of the past two decades. Instead of using the things just noted as arguments for federal aid through service to the nation as a whole, the author begins (p. 2) with a remark about the federal government "purchasing with federal funds a considerable measure of supervision over numerous" state activities.

The outlines of federal aid as extended to the seven main objects already mentioned are clearly and interestingly written. The substance of the entire book can be gleaned in two or three hours and such of the useful details as might be passed over in so quick a reading would be valuable for later reference. The brevity and clearness of the book should obtain for it many readers who would balk at a larger and more comprehensive survey—for which this may well prepare the way.

A more complete treatment of the subject would not let many pages pass before giving a clear-cut definition of federal aid. It would examine far more thoroughly than does this one how federal aid on its present large scale came to be and would attempt to show whether the federal government, the state governments or the people are responsible for it, and also the extent to which it results from the demands of the whole people or from some one or more social, professional or commercial class. Some of these things the author of the present book considers in passing and some he ignores. He also quite ignores the very fruitful field of foreign experience, particularly in

Great Britain, where "central aid," as it is there called, has gone far toward substituting Parliament and central administrative agencies for local governments. Although this is largely because of class, land ownership and taxation systems that do not prevail in America, the British experience deserves careful attention in this country.

Essentials of Steam Turbines to Date

REVIEWED BY A. G. CHRISTIE
Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md.

STEAM TURBINES—By Edwin F. Church, Jr., Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn. (First Edition.) New York and London: McGraw-Hill Book Co. Cloth; 6x9 in.; pp. 273, 225 halftones and line cuts. 17 tables. $3.

Steam turbines were invented and built before the thermodynamic theory of the flow of steam through nozzles and blades was thoroughly understood. Research and experiment are steadily adding facts to the fund of knowledge which correlates our known thermodynamic theory with turbine performance. Each new book on the subject must digest these new data and present the latest views on this correlation, which has advanced to that stage where turbine design and performance can now be based on known thermodynamic laws.

Professor Church has attempted this digest with the object of condensing the essential principles into a small book that would serve as a college textbook, and he has done his work well. Compared with other texts on this subject, the book is less voluminous and presents a later viewpoint of steam turbine theory and construction. It therefore will be welcome as a college textbook. At the same time his fundamental treatment of theory in a clear and logical manner will make the book worth studying by those older engineers who wish to understand the principles of modern turbines, their fundamental theory, the construction of condition curves and other information necessary in heat balance calculations. The author makes no attempt in this small book to include a consideration of the design of mechanical details.

The author assumes a knowledge on the part of the reader of thermodynamics, heat cycles and heat charts. His first chapter is devoted to a classification of the different types of turbines, with short descriptions and illustrations of each type. A careful selection and digest of the literature on nozzle phenomena has been made in the next chapter. The third and longest chapter in the book is devoted to blading phenomena, which are discussed from many angles, and many data are presented. The author would have avoided confusion had he used only one form of velocity diagram and method of calculation of work done in blading. Losses are well presented in the fourth chapter.

The various efficiencies of a turbine are clearly defined in the next chapter, together with a discussion of reheat factors, expansion in the turbine, and condition curves. In connection with the latter, the "leaving loss" correction has not been included. The sixth chapter, on methods of governing and their effects on steam consumption, is quite clear and simply stated. A better knowledge of these facts will result in more intelligent selection of turbines. Design methods in actual practice differ so widely that no attempt has been made in the last chapter to do more than indicate how thermodynamic methods can be applied to design. The book closes with a well-selected set of problems which show the application of the theory presented in the various chapters. There are a number of typographical errors in this first edition that will undoubtedly be corrected in later issues.

This book, although not a complete treatise on steam turbines, is one of the best available for American colleges and will also prove valuable and instructive to practicing engineers.

Publications Received

INTERLOCKING-RIB TILE WALLS, from the viewpoint of strength, have been studied by A. H. Stang, D. E. Parsons and A. B. McDaniel, of the U. S. Bureau of Standards. 10c. from Superintendent of Documents, Washington, D. C.

THE FALL RIVER CONFLAGRATION of Feb. 2, 1928, is the subject of pamphlet reports by the National Board of Fire Underwriters' committee on fire prevention, 85 John St., New York City, and the National Fire Protection Association, 40 Central St., Boston, Mass.

A SHORT STUDY of Maintenance-of-Way Charges Against Public Carrier Buses, by W. W. Hitchcock, assistant professor of civil engineering, Michigan State College of Agriculture and Mechanic Arts, is issued as Bulletin 85 of the Engineering Experiment Station at Ames, Iowa.

CONCRETE IN ARCHITECTURE is the subject of a handsomely made book of 59 pages consisting chiefly of illustrations in halftone and in color. There are also a few pages of text, devoted chiefly to painting decorations on concrete; technique for exposed aggregate concrete; molded concrete ornamentation; and stucco and plaster. The volume may be obtained free on application to the Portland Cement Association, Chicago.

WATER-SUPPLY PAPERS Nos. 596 G and H deal with chemical aspects of water. The first, Chemical Character of Waters of Florida, by W. D. Collins and C. S. Howard, was prepared in co-operation with the Bureau of Engineering and the Florida State Board of Health. The second, notes on Practical Water Analysis, is by Mr. Collins, who is chemist in charge, quality of water division, U. S. Geological Survey, Washington, D. C.

THE WATER RESOURCES OF RHODE ISLAND are described in a report by a Commission on Sources of Water Supply for cities and towns, submitted to the Legislature of 1928. Most of the report is a review of "The Quality of the Water Supply of Rhode Island," by Stephen De M. Gage, chief chemist and sanitary engineer, Rhode Island State Board of Health. Included with other material is a tabular description of the water-works of the state. (State Board of Health, Providence, R. I.)

AIRPORTS AS A FACTOR IN CITY PLANNING, by E. P. Goodrich, consulting engineer, New York City, is a 16-p. supplement to the March issue of *National Municipal Review*. (25c. from National Municipal League, 261 Broadway, New York City.) Besides the general discussion of the subject and the inclusion of one of the mathematical formulas to be expected in any of Mr. Goodrich's writings on city planning, this one being for the computation of length of runways at airports, the pamphlet contains three layout diagrams.

PRECAST CONCRETE WING PILES, as developed and improved by Louis Ravier, are described in his pamphlet, "Ravier Wing Piles." The varied use of this piling for quays, docks, jetties and retaining walls, etc., is pointed out, along with methods of construction, well illustrated. (See *Engineering News-Record*, Sept. 30, 1920, p. 658.) Copies may be secured from the author, 19 Avenue de Tourville, Paris, France; Arthur Surveyer, 511 St. Catherine St. West, Montreal, Que., Canada; and Maurice C. Couchot, 60 Sansome St., San Francisco, Calif.

THE DETROIT-WINDSOR BRIDGE over the Detroit River between the United States and Canada, as originally designed by Charles Evan Fowler and promoted by him and associates, is briefly described and illustrated in a pamphlet written by Mr. Fowler. This pamphlet, described as Part I, is to be supplemented by Part II, consisting of twenty photostats of general and detailed plans, estimates, etc. It should be understood that the bridge described is not the one which is to be built at the site indicated. (Part I, $1; Part II, $5; from the author, 25 Church St., New York City.)

THE PORT FACILITIES of San Francisco, Oakland, Berkeley, Richmond, Upper San Francisco Bay, Santa Cruz and Monterey, Calif., are described in Port Series No. 12, a joint publication of the Corps of Engineers, U. S. Army, and the U. S. Shipping Board. Like its predecessors, this report gives information regarding the port and harbor conditions, customs and regulations,

wrecking and salvage equipment, and railroad and steamship connections. The report contains excellent maps of the port, also airplane pictures. ($1 from Superintendent of Documents, Washington, D. C.)

A WEEKLY ENGINEERING INDEX SERVICE designed to make immediately available the index of various engineering and allied technical publications of the world, compiled by the American Society of Mechanical Engineers as an extension of the Engineering Index established 44 years ago, is "now in full swing." This means that subscriptions to the service are invited. Detailed information and samples of the index card may be obtained from Engineering Index Service, 29 West 39th St., New York City. There are thirteen main classifications in the index subdivided so as to give 118 subclassifications.

THE TRIENNIAL BOOK of A.S.T.M. Standards, dated 1927, is now available in two well-made volumes of 878 and 1,006 pp., dealing respectively with Metals and Non-Metals. Of the 340 standards in the two volumes, 63 relate to steel, nine to wrought iron, and the same number to pig and cast iron, while of Non-Metals there are 48 standards for cement, lime, gypsum and clay products, 31 for preservative coatings, 33 for road materials. ($17 and $9 respectively for either part in cloth or in half leather, and $14 and $17 for both parts from American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa.)

SLAG, ITS CHARACTERISTICS AND USES, is the subject of a series of bulletins being published by the National Slag Association, Cleveland, Ohio. Two numbers of the proposed long series of pamphlets have been issued: Absorption in Slag and Slag Concrete, and Resistance of Blast Furnace Slag to Abrasion and Wear. A careful search of technical literature has been made for articles, papers and test records relating to slag, and the meat of these discussions and records has been selected and is being printed, with references to original sources, in pamphlets of 20 to 30 pp. each, to be issued monthly.

STREET NAME SIGNS is a subject on which comparatively little information is available in printed form. The subject is presented in an 18-p. pamphlet by Adolph J. Post, senior assistant engineer, Public Works Department, city of Boston, and George H. McCaffrey, acting director of research, Merchants Association of New York. The pamphlet summarizes the results of an investigation made by the authors in Boston to determine the "most practicable size, style and placement of signs." Characteristics of an "ideal sign," and specifications for a sign are given. (25c. from Municipal Administration Service, 261 Broadway, New York City.)

THE HARBOR PLAN OF CHICAGO, a book published by the Commercial Club of Chicago, sets forth the results of a study of the harbor needs of Chicago made by a group of engineers appointed by the club when it was found that the city had no funds available for the purpose. The report gives complete data on present conditions and port facilities at Chicago, traffic, existing terminals and transportation facilities and proposed terminal facilities, together with information on seaports and river ports in general, port administration, and finally the subject of airports at Chicago. It is profusely illustrated with excellent maps, photographs and drawings. ($3.10 from Major Rufus W. Putnam, 608 S. Dearborn St., Chicago, Ill.)

RAIL STEEL, Its Endurance and Other Properties, is the subject of Technologic Paper 363 of the U. S. Bureau of Standards by John R. Freeman, Jr., R. L. Dowdell and William J. Berry. The pamphlet is divided into two sections: Part 1, Endurance Properties of Rail Steel, which describes the series of tests on the properties of rail steel carried out with particular reference to their resistance to repeated stress, including a suggested method whereby it may be possible to determine if rail steels in service are subject to stresses greater or less than their endurance limit; and Part 2, Comparative Properties of Rail Steel Cast in Standard Molds and Sink-Head Molds of the Gathmann type. (35c. from Superintendent of Public Documents, Washington, D. C.)

CONCRETE continues to be the subject of endless papers and discussions. Nearly the whole of the last issue of the *Journal* of the Boston Society of Civil Engineers (50c. a number, Tremont Temple, Boston) is filled by a paper on Concrete and Other Building Materials in Exposed Locations, by John J. Hardy, with discussions by eleven others. A more highly specialized paper, on The Effect of Climatic Changes Upon a Multiple-Span Reinforced Concrete Arch Bridge, by Wilbur M. Wilson, has just been made available as Bulletin 174, Engineering Experiment Station, Urbana, Ill. (40c.) This paper has many diagrams and some tabular matter and mathematical discussions aside from a description of the tests. The next bulletin in numerical order in the same series of publications (45c.) is on An Investigation of Web Stresses in Reinforced Concrete, this being Part 2 of the study, and being devoted to restrained beams. The authors are Frank E. Richart and Louis J. Larson.

IRRIGATION in various aspects is taken up in four recent pamphlets. Two of these are Technical Bulletins 47 and 67 of the U. S. Department of Agriculture (10c. and 20c. respectively, from Superintendent of Documents, Washington, D. C.), on Delivery of Irrigation Water, by Wells A. Hutchins, associate irrigation economist, and Silt in the Colorado River and Its Relation to Irrigation, by Samuel Fortier, senior irrigation engineer, and Harry F. Blaney, associate irrigation engineer. All three of these men are in the division of agricultural engineering, Bureau of Public Roads. From the Agricultural Experiment Station, University of Arizona (Tucson), comes The Use and Duty of Water in the Salt River Valley, by James C. Marr, associate irrigation engineer, U. S. Bureau of Public Roads, and a thin pamphlet, Weirs for Measuring Small Irrigating Streams (one of a series, Timely Hints to the Farmer). Prof. G. E. P. Smith, irrigation engineer, wrote the Hints and also a preface for the larger of these two pamphlets.

New Books and Revised Editions

[Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.]

THE AMERICAN ARCHITECTURE OF TODAY — By G. H. Edgell, Professor of Fine Arts and Dean of the Faculty of Architecture, Harvard University. New York and London: Charles Scribner's Sons. Cloth; 7x9 in.; pp. 401; 374 halftones. $6.

DER BAUINGENIEUR IN DER PRAXIS: Eine Einführung in die wirtschaftlichen und praktischen aufgaben des bauingenieurs —By Theodor Janssen, Professor, Reg.-Baumeister a.D. Zweite, neubearbeitete und erweiterte Auflage. Berlin: Julius Springer. Cloth; 6x9 in.; pp. 494; 23.5 reichmarks.

THE BEHAVIOR OF PRICES—By Frederick C. Mills, of the Staff of the National Bureau of Economic Research, with a Foreword by Edwin F. Gay and Wesley C. Mitchell, Directors of Research. New York: National Bureau of Economic Research, Inc. Cloth; 6x9 in.; pp. 598; $7.

THE DISPOSAL OF SEWAGE: A Text Book for the Use of Engineers, Sanitary Inspectors and Students—By T. H. P. Veal, B.Sc., A.M.I.C.E. Lecturer in Civil Engineering at the University of Birmingham. New York: D. Van Nostrand Co. Cloth; 6x9 in.; pp. 273; 44 line cuts and halftones. $4.25.

EVERYBODY'S AVIATION GUIDE: A Complete, Simplified Treatise in Question and Answer Form for Those Wishing to Obtain a General and Diversified Knowledge of Aeronautics and Aerodynamics. By Major Victor W. Pagé, Air Corps Reserve, U.S.A. New York: The Norman W. Henley Publishing Co. Cloth; 5x8 in.; pp. 247; 140 line cuts and halftones. $2.
Takes up "all types of aircraft," gives principles of their operation and describes their construction. Illustrations well chosen and presented, with adequate lettering of various parts.

HÖLZERNE DACHKONSTRUKTIONEN: Ihre Ausbildung und Berechnung—By Dr.-Ing. Th. Gesteschi, Beratender Ingenieur in Berlin. Vierte neubearbeitete Auflage. Berlin: William Ernst & Sohn. Paper: 7x9 in.; pp. 245; 313 illustrations, mostly line cuts. 12.4 reichmarks in paper or 14 bound.

INTRODUCTION TO AMERICAN ECONOMIC HISTORY—By Walter W. Jennings, Ph.D., Professor of Economics in the University of Kentucky. New York: Thomas Y. Crowell Co. Cloth; 6x9 in.; pp. 546; 100 charts. $3.

JAMES WATT AND THE STEAM ENGINE: The Memorial Volume Prepared by the Committee of the Watt Centenary Commemoration at Birmingham, 1919—By H. W. Dickinson and Rhys Jenkins. Oxford: The Clarendon Press. Cloth; 8x11 in.; pp. 415; 104 illustrations. $21.

METHODS AND COSTS OF TREATING MINE TIMBER: What to Treat and What Life to Expect—By L. D. Tracy, Coal Mining Engineer, U. S. Bureau of Mines, and N. A. Tolch, Research Fellow, Carnegie Institute of Technology. Pittsburgh, Pa.: Carnegie Institute of Technology. Paper; 6x9 in.; pp. 312; illustrated. $2.

THE PHILOSOPHY OF MASONRY ARCHES—By Sir Evan Owen Williams, K.B.E., B.Sc., M.Inst.C.E. [Selected Engineering Papers.] London: The Institution of Civil Engineers. Boards; 6x9 in.; pp. 34; 6 line cuts.

RÉSISTANCE DES MATÉRIAUX Appliquée aux Constructions: Methodes Pratiques par le Calcul et la Statique Graphique. Tome I. Par Ernest Aragon, Ingenieur des Arts et Manufactures, Ingénieur d'Etudes de Ponts, Constructions Metalliques et Travaux Publics. Deuxieme edition, revue par Paul Chamberlain, Ingénieur des Constructions Civiles. [Bibliotheque de L'Ingénieur de Travaux Publics.] Paris: Dunod. Paper 5x8 in.; 780; 409 line cuts. 71 francs.

SAFETY AND PRODUCTION: An Engineering and Statistical Study of the Relationship Between Industrial Safety and Production. A Report by the American Engineering Council. New York and London: Harper & Brothers. Cloth; 6x9 in.; pp. 414; 283 charts. $5.

THE THEORY OF STRUCTURES—By Charles M. Spofford, S.B., M.Am.Soc.C.E., M.Inst.C.E., Hayward Professor of Civil Engineering at the Massachusetts Institute of Technolgy. Third edition, revised and enlarged. New York and London: McGraw-Hill Book Co., Inc. Cloth, 6x9 in.; pp. 587; 414 line cuts. $6.

Letters to the Editor

A Forum for Discussion of Views of Engineers and Contractors

Sliding Probable Cause of Failure of St. Francis Dam

Sir—From what little I have read about the St Francis dam failure I believe cause was the same as that at Austin, Pa., and Austin, Tex. The rock underneath the masonry foundation probably had slippery joints or seams. I judge this by the fact that the rock adhered to the concrete base, so that probably sliding was more the cause of failure than seepage under the dam. Of course, the seepage under the dam would have been caused by a slight slide, and when a slide takes place, no matter how slight, it tends to lubricate the joint and accentuate the seepage. The prevention of this is in a heavy abutment cutoff wall under the downstream toe of the dam carried so deep that the weight of the downstream rock will prevent sliding.

The phenomenon mentioned is well understood by people who live in a landslide country. Sometimes the sedimentary rocks are so tilted on the side of the mountain that the joints have a slope of, we will say, 15 or 20 deg., and the stratifications may be separated by thin clay seams, which, when lubricated, will have a coefficient of friction of less than 20. The coefficient of friction between two smooth clean pieces of sandstone may be 50 or more.

Where the excavation goes down to 30 ft. below the stream bed, if the dam abutted against the rock for the whole vertical distance of 30 ft. on the downstream side, that weight of downstream material would probably be sufficient to prevent the movement due to sliding, even if there were clay slips.

Some of the circumstances, including the fact that the center portion of the dam, where it extended farthest down, remained intact, strengthen my conclusion, or, rather, suspicion.

J. W. LEDOUX,
Consulting Engineer.

Philadelphia,
March 27, 1928.

St. Francis Dam Failure Due to Lack of Geological Study

Sir—Commenting upon the report by Nathan A. Bowers on the St. Francis dam failure in your issue of March 22, permit me to say that while Mr. Bowers has given a very excellent description of the dam and the conditions that existed there, I cannot agree entirely with the theory that both the east and west abutments gave way simultaneously. If one side gave way even so much as a few seconds ahead of the other, the pressure upon the remaining side would begin to drop, and if the dam could withstand the pressure until it was relieved, there is no reason why it should fall or why it fell after the pressure was lessened.

My opinion is that the leakage *undermined the dam* throughout a large part of its foundation and that the breaks on either side of the center are shear breaks, if the center has not been moved. On the other hand, if the center did move, the shear would be the same. Doubtless a survey on the old notes will tell whether the center has moved, but it appears to me that the dam gave way *from the center* first and not from the abutments.

For two days the water had been increasing in the Santa Clara River. More than seventeen hours before the break the flow had increased 1,500 miner's inches (testimony before the coroner's jury). Now, 1,500 miner's inches of water coming through or around the abutments would have made the most ignorant layman start running, but the leak was an invisible leak.

There is a great geological fault extending across the state from the vicinity of Santa Barbara almost to Imperial Valley, crossing some miles away from where the St. Francis dam was located and across the mountains north of San Bernardino.

This fault is well marked on all geological maps as the San Andreas fault. The Santa Barbara earthquake in 1925 and the San Bernardino earthquake, as well as many little temblors, have been traced to movements on that San Andreas fault plane. Little temblors have been noted in Los Angeles many times, even farther away from the fault than the dam site. I believe that one, or some, of these little earthquakes may have cracked the dam or possibly loosened the underlying shale until the undermining occurred and the dam sheared.

If there was any faulty construction—and William Mulholland, chief engineer, says he will assume such blame (testimony)—I think it was solely in not going deep enough with some parts (or all) of the foundations, and not in the wing abutments. I am inclined to lay the blame more strongly to the lack of sufficient geological study than to errors in engineering calculations.

I cannot think that both wings would break from the abutments simultaneously. I cannot conceive of 1,500 miner's inches of water leaking through the abutments or around them without being seen and frightening even the laymen.

In conclusion, it is well to remember that the dam was built in a known zone of many and frequent little earthquakes, subject occasionally to quakes that are more severe, and I repeat that the error is probably more geological than in the construction mathematics.

LETSON BALLIET.

Reno, Nev.,
March 31, 1928.

[Mr. Bowers did not say that "both the east and west abutments gave way simultaneously." What he said in the opening paragraph of his report was that the "great structure suddenly broke up," meaning that the original failure was sudden. Subsequently, in his detailed description of the failure, Mr. Bowers said: "The fact that all the fragments from the right gap were carried far, while those from the left gap were moved but little, indicates that the initial failure occurred on the right side of the stream." Also, in the editorial comment it was said: "Here [the left section] sliding due to the push of the impounded water cannot be in question, for the evidence of the wreckage shows that failure occurred after the water was drawn down."—EDITOR.]

A Civic Duty for Municipal Engineers to Preserve Historical Data

Sir—While in the office of Edward S. Rankin, engineer in charge, Bureau of Sewers, Newark, a day or so ago, he showed me a copy of a booklet containing a collection of historical articles which he has written from time to time for the local press. These articles are based on old records, sewer excavations and his general experience in connection with his sewerage work for many years in Newark.

Altogether these articles form a fascinating and, in my opinion, most valuable record of certain features of early local history. Their scope varies tremendously; for example, from the location of the now lost Bound Brook, up which ships formerly sailed to the center of Newark, to evidence of an old Indian prohibition enforcement officer in the days of the first Dutch settlers in New York who had problems in many ways similar to those of the present day.

It occurred to me, after glancing over this booklet, the entire edition of which was almost immediately taken up, that many engineers throughout the country might be in a position to put in permanent form many interesting local historical data which the local press would be interested in publishing from time to time. It seems almost a civic duty for them to preserve such information in some permanent form, since otherwise it would ultimately be lost.

I am writing you thinking that possibly a reference to Mr. Rankin's work in your columns might encourage other engineers to make the necessary effort to preserve similar information relating to their cities.

HARRISON P. EDDY, JR.

Boston, Mass.
March 20, 1928.

News of the Week

Current Events in the Civil Engineering and Contracting Fields

All St. Francis Dam Reports Agree as to Reason for Failure

Defective Foundations Generally Accepted as the Cause of Failure of Structure

OF THE various boards and commissions appointed to investigate the St. Francis dam disaster as listed in *Engineering News-Record*, April 5, p. 561, reports have now been filed by those appointed by Governor Young, the Los Angeles County district attorney, the Los Angeles City Council, the Los Angeles Bureau of Water Works and Supply, and the coroner's jury. It is notable that these reports are all in close agreement; some go into more detailed analysis than others and some feature remedial recommendations, but as to the cause of failure all are in accord.

For example, the district attorney's committee found failure "due to defective foundation materials, some of which, while reasonably hard when dry, became soft and yielding when saturated with moisture." The committee of three geologists reporting for the water bureau stated that "there were weaknesses in foundation under both left and right abutments sufficient to have caused failure." The findings of Governor Young's committee ascribing the failure to foundations was abstracted in the April 5 issue. The Los Angeles City Council's committee features "defective foundation" as the cause, and the coroner's jury found the destruction of the dam to be caused "wholly or in part by the failure of the rock formation on which it was built."

Coroner's Jury Findings

The coroner's jury conducted exhaustive hearings extending over several weeks, and being the last of the five investigating bodies to report, had read into its testimony findings of the four others. The jury placed responsibility on "the Bureau of Water Works and Supply and the chief engineer thereof" and also on "those to whom the chief engineer is subservient," but recommended that there be no criminal prosecution. In the jury's findings stress is placed on two errors: (1) Deciding upon the type of structure to be built upon foundation of this character, and (2) the fundamental error of the public in permitting through lack of action so great a responsibility to rest upon a single individual.

Those reports in which the dynamiting possibility was mentioned at all scouted this theory. The theory of earth movement as a possible cause was also generally discredited. The desirability of checking existing structures was pointed out, and recommendation regarding needed laws concerning more rigid requirements for future dam construction was mentioned in several reports.

A more detailed review of the findings of the several committees will be presented in an early issue.

Fire-Swept Center of Fall River Being Replanned

Tentative plans for wider streets and for the location of new public buildings in the area swept by the conflagration at Fall River, Mass., on Feb. 2, 1928, have been submitted by Arthur A. Shurtleff, city planner, Boston, Mass. Following the fire the planning board, the city engineer, the chairman of the emergency committee of the board of aldermen and Mayor W. Harry Monks took up the matter of replanning the burned area of eight to ten acres. It was decided to grant no building permits in the fire-swept area until after the new plan was ready. Under the proposed plan street widenings totaling about ½ mile in length are proposed, designed to make better provision for air, light and the movement of vehicles and pedestrians. Greater street width combined with a plaza between proposed sites for a new city hall and a new post office building is expected to afford fire stops. The United States government has agreed to rebuild and enlarge the old post office, making it practically a new building, at an expense of from $1,000,000 to $1,500,000. The city hall was not burned, but it is so old and inadequate that a new building is proposed at the location already mentioned. A large new hotel on the site of the old Mohican House is proposed. James A. Burke is chairman of the Fall River Planning Board.

New Jersey Postpones Action on Delaware River Compact

Action on the Tri-State Delaware River compact was postponed until its July recess by the New Jersey Legislature at the close of its regular session. Meanwhile a special legislative committee is expected to study the subject, including objections to the compact made by the city of Trenton, through legal counsel and in engineering reports by Robert E. Horton, Albany, N. Y., and Ezra B. Whitman, Baltimore, Md.

St. Lawrence Waterway Under Discussion by The Two Countries

Both Canada and the United States Are in Close Accord as to Basis of Treaty

THAT the governments of Canada and the United States are in close agreement as to the basis upon which discussion of a treaty for the construction of the St. Lawrence Waterway may be begun is the gist of correspondence between the State departments of the two countries, recently made public.

Since the Joint Board of Engineers submitted its report on the proposed deep-draft waterway in the St. Lawrence River in November, 1926 (*Engineering News-Record*, Dec. 2, 1926, page 906), little has developed looking toward the negotiation of a treaty for the construction of the waterway. Now the State departments of the two governments have given out the recent correspondence on the subject, which indicates that both governments believe that discussion looking toward the negotiation of a treaty should be undertaken and that the differences of opinion as to the grounds upon which the treaty should be based are not great enough to be of importance. The delay in reaching this conclusion has been due in large part to the fact that the Canadian National Advisory Committee did not make its final recommendations to its government until January of this year. At that time it recommended that the work should be undertaken but that fuller allowance should be made for future requirements by providing, in addition to a 30-ft. depth for permanent structures, a 27-ft. depth in the navigation channels as opposed to the 25-ft. depth recommended by the joint board. The committee also stated that the advisability of undertaking the work at the present time depends upon the solution of a number of financial and economic problems and upon further consideration of certain engineering features as to which the two sections of the joint board are not yet agreed.

Financial Problems

On the assumption that the United States will reap greater benefit from the construction of the waterway, the Canadian advisory committee recommends that the American government contribute a larger portion of the cost of the joint undertaking. Also, that as Canada is opposed to the export of power, the development of power

on the Canadian side should not exceed the capacity of the Canadian market to absorb it. The committee also takes into consideration the fact that in the work of deepening the St. Lawrence both above and below Montreal, and in the construction of the Welland Ship Canal as a necessary link in the St. Lawrence waterway system, Canada should be credited with the expenditures in a distribution of the costs. On this basis the Canadian committee suggests the following distribution of costs:

CANADA		
Present Works:		
St. Lawrence ship channel	$30,000,000	
St. Lawrence and Welland canals	50,000,000	
Lock at Sault Ste. Marie, Ont	5,560,000	$85,560,000
Proposed Works:		
Welland ship canal	$115,600,000	
Wholly Canadian section, St. Lawrence shipway, 27-ft. navigation and development of 949,300 hp	199,670,000	315,270,000
Total for Canada		$400,830,000
UNITED STATES		
Present Works:		
Dredging St. Clair and Detroit rivers	$17,536,000	
Locks at Sault Ste. Marie, Mich	26,300,000	$43,836,000
Proposed Works:		
International section St. Lawrence shipway, 27-ft. navigation and initial development of 597,600 hp	$182,157,000	
To complete development additional power 1,602,000 hp	92,090,000	
Upper lake channels to 27 ft	65,100,000	339,347,000
Total for United States		$383,183,000

ALLOCATION OF WORK

Several methods of constructing the waterway have been considered by the Canadian National Advisory Committee, but the final method which chiefly commends itself to the committee is, in brief, that Canada should construct the waterway in the section wholly Canadian—that is, the Welland Ship Canal and in the St. Lawrence below the International boundary—and that the United States should undertake the completion of a 27-ft. waterway to the head of the lake in addition to meeting the entire cost of the development, under joint supervision, of the international section of the St. Lawrence, both for navigation and for power. The construction of the wholly Canadian (Welland and St. Lawrence) section and, if the United States should see fit, of the upper lake works would on this plan be given precedence of the international section because of the necessity of providing for further consideration of the engineering problems involved in the international section and of permitting reasonable absorption of the power developed on the Canadian side.

The United States government does not entirely agree with this conclusion, more particularly to the inclusion of the cost of work on the old Welland Canal and the St. Lawrence except as they may be available for the new system, nor does it agree that the work in the international section should be delayed until the question of disposition of power in Canada is settled, as it believes that the work should be prosecuted in such a way as to have all parts completed at about the same time. It also feels that even though Canada cannot now absorb all the power that will become available in this section, it still should bear its share of the cost of construction which is assignable to power. The United States government agrees that all power developed in Canada and half the power developed in the international section belongs exclusively to Canada regardless of who builds the work for its development.

The United States government recommends that the two countries proceed with the appointment of commissioners to discuss jointly the problems presented by the two governments without waiting for an agreement on the part of the engineers on the points over which they still disagree.

State Will Not Maintain County Highways in New York

A bill providing for the maintenance of county highways at the sole expense of the state, passed by the Legislature of New York, has been vetoed by Governor Smith. In a memorandum accompanying the veto the Governor said:

"The object of the bill is to relieve the towns from paying the $50 per mile tax and the villages from paying the 1½c. per sq.yd. tax which they now pay toward the maintenance of state highways. If the policy of our state department of highways were bad, I would approve this bill, but I am informed by the department of public works that our policy is not only good for the state but for the local communities, since the cost of maintaining the ordinary earth road is more than $50 per mile."

Mechanical-Electrical Bureau of Baltimore Enlarged

All the mechanical and electrical operations in the Department of Public Works of Baltimore, Md., have been transferred by order of Charles F. Goob, chief engineer of Baltimore, to the mechanical-electrical bureau, the activities of which heretofore have been confined to the electric conduit system and street lighting. The transfer relieves Edward G. Rost, water engineer, of the class of work indicated, Walter G. Hammond, engineer of buildings, of electrical inspection, and Frank W. Jacoby, commissioner of street cleaning, of the operation of the two rubbish salvaging and incinerating plants. These two plants have been put in charge of W. Rayner Straus, a mechanical engineer, with Covington K. Allen as engineering assistant. Mr. Goob, who before his appointment as chief engineer of Baltimore was head of mechanical-electrical bureau, has continued its oversight, but a chief of the enlarged bureau is to be appointed by the mayor.

Activated-Sludge Process Indorsed for New York City

The activated-sludge process for the proposed 185-m.g.d. sewage-works on Ward's Island, noted in *Engineering News-Record*, Dec. 8, 1927, p. 935, has been indorsed by C. W. Berry, Comptroller, and Arthur S. Tuttle, chief engineer, Board of Estimate and Apportionment, who were appointed a committee on March 30 to "make a survey and report on the pollution of New York harbor and to inspect methods of sewage disposal in use in other cities." Their report states:

"Your committee is of the opinion that the conditions which exist in the East River and in the Harlem River in the vicinity of Ward's Island demand the utilization of the most efficient treatment process that is available and that the activated-sludge process meets this requirement, the sludge being disposed of either at sea or by conversion into fertilizer." The committee adds that a survey of the tributary area indicates that industrial waste in the sewage would not "interfere with the successful operation" of an activated-sludge plant, but that more drastic measures might be taken than are now in effect to exclude oil and gasoline from the sewers.

The Ward's Island plant, the committee believes, should provide conversion of the sludge into fertilizer either at once or after further studies have been made, and that the plant for production of fertilizer should be so located that it would be available for serving "as many of the additional sludge-producing plants as may be found practicable" and at a point "where shipping facilities can be provided." Additional activated-sludge plants are recognized as possibilities at Jamaica, at Sheepshead Bay and at Hendrix St., Brooklyn, at which points the Board of Estimate and Apportionment "has already recognized the necessity for introducing a process at least equal in efficiency to the activated-sludge process at some future time."

Stress is laid in the report of the committee on the need of employing civil, mechanical and electrical engineers, and also chemists and biologists of a high order of ability and large experience to construct and operate the activated-sludge plant "if the difficulties which have been encountered elsewhere" in the operation of such plants "are to be avoided."

The conclusions of the report are based largely on an inspection trip by Messrs. Berry and Tuttle, accompanied by Kenneth Allen, sanitary engineer to the Board of Estimate, and, part of the way, by George W. Fuller, consulting engineer, New York City, to ten activated-sludge plants, including those at Milwaukee, Chicago, Houston, Tex., and Pasadena, Calif. The detailed report on the various plants visited is to be submitted later on by Mr. Allen.

Kansas City to Vote on Bond Issue for Public Improvements

The citizens of Kansas City, Mo., will vote on May 8 on the authorization of a bond issue of $18,500,000. Of this amount $3,000,000 is for improvements in the water department, $5,500,000 for traffic ways, $3,750,000 for a new city hall, $3,500,000 for a municipal auditorium and $500,000 for docks and warehouses.

Piedmont & Northern Railway Extension Disapproved

Authority to construct two extensions of the Piedmont & Northern Railway, one from Spartanburg, S. C., to Gastonia, N. C., and one from Charlotte to Winston-Salem, N. C., has been denied by the Interstate Commerce Commission on the ground that the evidence presented does not warrant paralleling the Southern Railway closely for a distance of 53 miles. The Piedmont & Northern Railway now operates two lines, one in North Carolina and one in South Carolina. It proposed to connect those two lines and extend on to Winston-Salem. The extensions were opposed by other railways in the region as being unnecessary. Comment upon the issues involved in this extension was given in *Engineering News-Record*, Oct. 27, 1927, p. 658. A complete copy of the commission's findings is not yet available for abstract.

Windbracing of Tall Buildings to Be Studied

A study of data bearing on the problem of windbracing of tall buildings is to be carried out through the instrumentality of a research fellowship established at Ohio State University, Columbus, by the American Institute of Steel Construction. One phase of the study will be the observation of stresses in the members of the steel frame of the American Insurance Union tower in Columbus, whose columns during construction were equipped with gage points to permit measurement of deformations under stress while the building is in service. It is expected that a committee of the Structural Division of the American Society of Civil Engineers will co-operate in studying and interpreting the data obtained through the proposed research work.

Engineering Societies Seek Fund of $7,000,000

Endowment of $7,000,000 is sought for the Engineering Foundation and the Engineering Societies library, it is announced by the board of trustees of the United Engineering Society, representing the national societies of civil, mining and metallurgical, mechanical, and electrical engineers. One fund of $5,000,000, it is planned, will be applied to the research projects of the Foundation, and a second fund of $2,000,000 to the maintenance of the library. The Foundation was established thirteen years ago with a gift of $500,000 from Ambrose Swasey, engineer and manufacturer, of Cleveland, Ohio. This amount has been increased to about $625,000. The Engineering Societies Library, at 29 West 39th St., New York City, is one of the largest technical libraries in the world and demands upon its service have outgrown its resources.

Reports From Nine States on Frost Damage to Highways

The surveys being made by the states in the frost zone to determine winter damage to highways have now reached a stage where approximate summaries are possible. Telegraphic reports in response to direct inquiry are now coming in and the following from nine states are given here. Other reports as received will be published in future issues.

Massachusetts, A. W. Dean, state highway engineer: Expenditures for correcting frost breaks estimated not to exceed $50,000; intermittent breaks on about 500 miles.

New Hampshire, F. E. Everett, highway commissioner: Frost damage somewhat more serious than in recent previous seasons owing to heavy rains in fall filling ground with water, very little snow and consequent frost action. No estimate of mileage or cost of repairs.

Vermont, H. E. Sargent, state highway engineer: Frost damage sufficient to interfere with traffic is only on gravel roads; roads froze last fall with ground saturated with water; cold weather and little snow sent frost deep. Roads in flood area most affected; flood removed some gravel surfacing and left layer of silt, with the result that they cut through excessively this spring. Alternate warm and cold weather this spring, with above unfavorable conditions, has delayed drying out. Some say that outside of flood area conditions are normal.

Illinois, F. T. Sheets, state highway engineer: We have not had any excessive frost damage on the paved state highway system during the past winter and only appreciable frost action on county gravel roads.

Minnesota, J. T. Ellison, state highway engineer: It is not possible to determine frost damage to highways until breakup is over. Two thousand miles affected. Loss to traffic and business probably greater than direct damage to roads.

Wisconsin, H. J. Kuelling, state highway engineer: Frost damage smaller than usual; $50,000 should repair damages.

Ohio, H. J. Kirk, state highway engineer: We estimate amount of damage about one-half what it was for the winter one year ago. Our guess is, and I consider it as merely a guess, that this damage amounts to between $200,000 and $300,000, affecting some miles of road very little and others seriously.

Nebraska, Department of Public Works: Excessive frost damage covered not to exceed 50 miles.

Oregon, R. A. Klein, state highway engineer: Excessive frost damage 50 miles; approximately $43,000 damage.

Washington Notes

Flood-Control Under Discussion In the House—Federal Aid Bill Delayed—Hydraulic Laboratory

By Paul Wooton
Washington Correspondent

FLOOD-CONTROL legislation is scheduled for consideration in the House of Representatives throughout the week. The administration gained a point in this controversy by sweeping away the limitations on amendments and debate which some of the advocates of the bill desired. The general debate is to last three days, with Representative Reid, of Illinois, chairman of the flood-control committee, in charge of the time for the proponents for the bill, and Representative Frear, of Wisconsin, a member of the committee, in charge of the time for those who oppose the measure in its present form.

Administration amendments propose to reduce the appropriation from $325,000,000 to $297,000,000. A concession is made in the matter of local contributions by reducing the amount from 20 per cent, provided in the Jadwin report, to 10 per cent. A limitation of $10,000,000 is placed on the amount which may be expended on the tributaries, and changes are made restricting the compensation clause. The administration amendments would require the city of New Orleans to take care of damage claims arising from the construction of the spillway at Bonnet Carré, while a similar provision is made for the payment of damages arising from the New Madrid floodway by southwestern Illinois and southeastern Missouri, either jointly or severally. There is every evidence that these amendments will be strongly resisted.

Federal Aid for Highways

The highway bill, authorizing a continuance of federal aid at the rate of $75,000,000 annually, has been reported favorably to the House. A minority report from the committee, however, urges that federal aid be extended at the rate of $100,000,000 per year.

Hydraulic Laboratory

The Senate on April 13 passed the Ransdell bill, authorizing the establishment of a national hydraulic laboratory in the Bureau of Standards. A similar bill was introduced by Senator Ransdell in 1922 at the request of American Engineering Council in an effort to carry out a recommendation made by John R. Freeman. The commerce committee on two previous occasions reported the bill favorably and urged its passage, but it took the flood of 1927 to muster the necessary support behind the bill to insure its passage. The bill was supported strongly by Secretary Hoover. It authorizes an appropriation of $350,000.

Brief News

PUBLIC IMPROVEMENT bond issues totaling nearly $78,000,000 were buried in the anti-Thompson landslide at Chicago on April 10. The total is not only the largest aggregate of bond issues ever submitted to the voters of Chicago but was slightly larger than the present city debt for all purposes.

THE PERUVIAN GOVERNMENT has signed a contract with the Frederick Snare Corporation, of 114 Liberty St., New York, for four concrete piers, bulkheads and stone breakwaters, together with a number of warehouses, the whole making a new port at Callao harbor which will make this harbor one of the most modern steamship terminals in South America. The completed terminal is to cost in excess of $6,000,000 and will make it possible for steamers to lie alongside the piers and discharge or take on freight without the necessity of using lighters. This new port is to be called Terminal Leguia and the contract involves the dredging of the entrance to the port.

A BOND ISSUE of $7,284,000 for local improvements, minor in extent and various in character, designed to serve "Mr. Average Citizen" is to go to popular vote at Pittsburgh, Pa., April 24.

THE ORLEANS LEVEE BOARD has contracted with the Harland-Bartholomew Company to lay out plans for the utilization of the $15,000,000 reclamation and parking development on the shores of Lake Pontchartrain at New Orleans, according to a report of the board of commissioners of the Port of New Orleans. The lake-shore project involves reclaiming about 2,000 acres of land within the limits of the city to be variously used for public parks, bath houses, athletic fields and residential sites.

TO PREVENT THE STEALING of red signal lanterns placed on street and sewer work in the Colorado city named below, the lanterns are now stamped with the words: "Stolen From the City of Colorado Springs."

A THIRD GENERATING UNIT in the Skagit power house will afford approximately 37,500 hp. when it is completed in the winter of 1928-29, as a result of funds provided in the $2,000,000 bond issue approved by the Seattle City Council. Mayor Landes has approved an ordinance appropriating $625,000 for this unit.

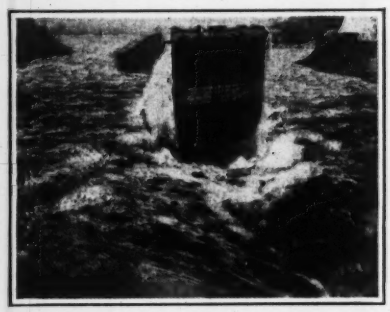
A BOND ISSUE of $30,000,000 to finance the extension of Detroit's sewer system was approved by the voters at the April 2 election. It is expected that approximately $10,000,000 will be spent during the next twelve months. Plans are being prepared under direction of Perry A. Fellows, city engineer, for several projects, and it is the intention of the Department of Public Works to advertise for bids on the first group of major contracts about June 1. These contracts will include several cylindrical sewers ranging in size from 4 ft. to 15 ft. inside diameter to be constructed in tunnel.

Random Lines

A Flood That Flowed Uphill

On the front cover of a booklet illustrating the St. Francis dam disaster and issued by the American Autochrome Company, 300 West Grand Ave., Chicago, there appears the picture reproduced herewith with the title, "Air View of the Broken Dam Showing the Torrent Sweeping Down the Canyon."

Engineers will be shocked, however,



to find that the "torrent" is shown moving upstream, cascading precipitately from the downstream face of the standing section of the dam around both its sides into what appears to be a great hole on the *upstream* side of the dam. For an "air view" of a break that occurred at midnight, truly this can be said to be a remarkable picture.

The Sleepy Make-Up Editor

Salem, N. J., to Dedicate Bridge.

Special to The New York Times.

SALEM, N. J.—Thousands of visitors are expected here Saturday afternoon, when the new Penn's Neck Bridge, costing $300,000 and one of the largest spans in inland south Jersey, will be dedicated with a parade and other public ceremonies.

Brown Alumnae to Give a Bridge.

To add to the funds for the Alumnæ Hall recently opened on the campus of the Women's College at Brown University, the Brown Alumnæ Club of New York will give a bridge party in the Waldorf next Friday evening.

A Water Pipe Mystery

Whilst the borough council men were cleaning the pipes in Firebrace St. last week they were surprised at discovering a lengthy obstruction which came to view. After an inspection of the 4-in. pipe, this big "stopper" was found to be 12 lb. of lead. The only solution of its presence was that when the pipes were joined many years ago the lead had accumulated into a spear-like shape and so had obstructed the flow of the water until the supply could only percolate through a half-curved depression.

Personal Notes

F. O. DUFOUR, head of the civil engineering department of Lafayette College, Easton, Pa., has been appointed consulting engineer for the United Engineers & Constructors, Inc., with headquarters in Philadelphia. Mr. Dufour is a director of the American Society of Civil Engineers and secretary of its research committee; member of the committee on iron and steel structures of the American Railway Engineering Association; member of the executive committee of the National Committee on Wood Utilization, of the joint committee on unit stresses in structural steel and of the board of managers, Lehigh Valley Engineers' Club. For the past seven years he has been at Lafayette College. Previous to that time he was for a number of years assistant chief and then chief structural engineer for Stone & Webster, in charge of all structural engineering.

SAMUEL A. HART has been appointed city engineer of Sacramento, Calif., succeeding Allan J. Wagner, resigned. Mr. Hart has been serving for some time as assistant city engineer, from which position he was advanced on the resignation of Mr. Wagner.

GEORGE W. SIMONS, JR., has been indorsed by the city planning advisory board for the position of city planner of Jacksonville, Fla. Mr. Simons has been chief engineer for the state Board of Health for nine years and chief engineer and vice-president of the Consolidated Engineering & Development Company for three years. He is also consulting engineer for Tampa, Fort Myers, St. Augustine and Starke. Mr. Simons is a graduate of the Massachusetts Institute of Technology and is president of the Florida Engineering Society.

ALEXANDER A. DEDOULOFF, who has been engaged in the design and construction of the Holland tunnel, is now associated with the Lago Petroleum Corporation, Maracaibo, Venezuela. Mr. Dedouloff is a graduate of the Massachusetts Institute of Technology and previous to his work on the Holland tunnel was with the Chicago Great Western Railroad and later was engaged on the design and construction of the St. Paul union depot.

JOHN MCGREW, who served in the engineer corps on the building of the Moffat tunnel, has accepted a position with the Denver & Salt Lake Railroad, with headquarters in Denver.

W. H. LYNCH, formerly district engineer, U. S. Bureau of Public Roads, at Omaha, Neb., has been appointed district engineer for district No. 1, embracing Oregon, Washington, Montana and northern Idaho. Mr. Lynch succeeds C. H. Purcell, formerly head of district

No. 1, who recently accepted the position of California state highway engineer. Mr. Lynch, a graduate of Lehigh university, has been with the Bureau of Public Roads for the past fifteen years.

R. W. LINCOLN has been engaged as chief engineer in charge of the design and construction of the hydro-electric developments of the West Canadian Hydro Electric Corporation, Ltd. The first unit of the corporation's 15,000-hp. program is being constructed on the Shuswap River near Vernon, B. C. Mr. Lincoln is a graduate of the University of Washington and spent five years with the U. S. Reclamation Service prior to ten years' work around Portland, Ore., in private practice and structural work.

WILLIAM J. MURRAY, formerly secretary-treasurer and general manager of the Feeney & Sheehan Building Company, and JOSEPH A. MURRAY, JR., announce the formation of the William J. Murray Construction Company, Inc. The company will have offices in Albany, N. Y., and will do business as general contractor and engineer and serve clients with appraisals and expert testimony.

W. G. STROMQUIST has been appointed director of the division of sanitary engineering and of the division of rural sanitation, Jefferson County board of health, Birmingham, Ala. Mr. Stromquist was graduated in municipal and sanitary engineering from the University of Illinois in 1910 and since that time has been engaged in sanitation work in various localities. During the World War he was in charge of mosquito control and other sanitary engineering problems at Muscle Shoals and later was officer in charge of the Muscle Shoals sanitary district.

PAUL A. BANKSON, now chairman of the board of appeals on zoning, will be appointed city planning engineer of New Rochelle, N. Y., it is announced by Mayor B. B. Badeau of that city.

EDWARD G. SHEIBLEY has resigned from the position of consulting engineer and superintendent of safety, California Industrial Accident Commission, and has opened offices in the Balboa Building, San Francisco, as consultant in accident prevention and industrial management. Prior to service with the Accident Commission, Mr. Sheibley was successively sanitary engineer for the U. S. Public Health Service, hydraulic engineer for the California Department of Public Works and director of the Bureau of Housing and Sanitation.

K. H. TAPPAN, until the first of the year employed by the Duke-Price Power Company, Ltd., on Lake St. John protection work, is at present field engineer on the hydro-electric development at Chute-a-Caron, Quebec, the work being carried on by the Alcoa Power Company, Ltd. Mr. Tappan is a graduate of the Princeton Engineering School, class of 1925.

Engineering Societies

Calendar

Annual Meetings

BUILDING OFFICIALS CONFERENCE OF AMERICA, Springfield, Mass.; Annual Meeting, Detroit, Mich., April 24-27.

AMERICAN WELDING SOCIETY, NEW YORK; Annual Meeting, New York, April 25-27.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston, Mass.; Annual Meeting, Atlantic City, May 7-10.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago; Annual Convention, El Paso, Tex., June 4, 5 and 6.

AMERICAN WATER WORKS ASSOCIATION, New York; Annual Convention, San Francisco, week of June 11.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION; Annual Meeting, University of North Carolina, June 25.

AMERICAN INSTITUTE OF QUANTITY SURVEYORS, Chicago; Annual Convention, New York, June 25-27.

TENNESSEE ROAD BUILDERS' ASSOCIATION—John S. Humbard, of Knoxville, was re-elected president and R. H. Baker, of Nashville, was re-elected engineer manager of the Tennessee Road Builders' Association at its first regular membership meeting in Nashville March 30. Other officers re-elected were J. S. Dunbar, Nashville, vice-president; D. L. Brown, Chattanooga, vice-president; F. V. Ragsdale, Memphis, vice-president, and C. H. Simpson, Nashville, secretary-treasurer. Another meeting of the association is to be held within the next month.

SEISMOLOGICAL SOCIETY—On April 30-May 2 the Eastern Section of the Seismological Society of America will hold its third annual meeting at the University of Virginia, Charlottesville. A number of papers on instruments, on the relation of earthquakes to tectonic movement, on analysis of seismograph records and on the earthquake hazard in the United States will be discussed. Local arrangements are in charge of Prof. W. A. Nelson. Dr. E. A. Hodgson is acting chairman of the section, and N. H. Heck, of the U. S. Coast and Geodetic Survey, is secretary.

THE FLORIDA SECTION of the American Water Works Association held its second annual meeting in Orlando on April 3 and 4. The high water mark of attendance was 114. J. E. Gibson, president of the A.W.W.A., was present and made an address on the subject "Not Good if Detached," stressing the point that every water-works superintendent or operator should be a member of the section nearest to him. Jacksonville was chosen as the place for the next annual meeting.

THE BOSTON SOCIETY OF CIVIL ENGINEERS at its eightieth annual meeting last month elected Prof. Charles B. Breed, of the Massachusetts Institute of Technology, president. Other officers elected were: Vice-president, Arthur T. Safford, of Lowell; treasurer, Frank O. Whitney, of Boston; secretary, Prof. J. B. Babcock, of the Massachusetts Institute of Technology.

THE CALIFORNIA CHAPTER of the Associated General Contractors of America has been formed with the following officers: C. E. Bressler, of Santa Ana, president; E. Paul Ford, of San Diego, vice-president; H. H. McQuiddy, of Santa Barbara, secretary-treasurer.

THE FOURTH ANNUAL EASTERN SAFETY CONFERENCE will be held in the Public Service Auditorium, Newark, N. J., on April 26. An innovation this year will be two special sessions for representatives from chemical plants.

Obituary

ALLEN J. HILL, vice-president of the Braun, Bryant & Austin Company and a director of Western Asphalt Association, prominent in construction work in the West for the past twenty years, died in Los Angeles, Calif., on March 29 from injuries sustained in an automobile accident. He was Northwest manager of the Warren Brothers Paving Company when that concern built many Western roads, including the Columbia Highway. Mr. Hill was 48 years old.

JOSIAH FOSTER FLAGG, retired civil engineer, aged 92 years, died on April 13 in Santa Barbara, Calif., where he had lived since his retirement twenty years ago. Mr. Flagg was a graduate of Harvard and during his active engineering career had charge of important works in Mexico, South America and the West Indies, as well as in many sections of the United States.

WILLIAM JOHN GRAHAM, of Ottawa, Ont., died on April 9 following an illness of about two months. He was 69 years old. Mr. Graham was for some time on the staff of the Canadian Pacific Railway, and 29 years ago went to Ottawa to join the staff of the Department of the Interior. Five years later he again entered the service of the C.P.R. in connection with important irrigation works in Alberta. He was later associated with the National Transcontinental, with the Ontario Hydro Electric Commission and with the Gatineau Power Company.

FREDERICK MEISTER, consulting engineer on the Cathedral of St. John the Divine in New York City and well known as a designer of theaters in many sections of the United States, died suddenly on April 1 at his home in Union City, N. J. He was a member of the American Society of Civil Engineers and vice-president of the Hinkle Steel Construction Company, of New York City.

Construction Equipment and Materials

A Section Devoted to What the Manufacturer Is Doing for the Engineer and Contractor

Standardization of Solid Section Steel Windows

Simplified Practice Recommendation No. 72 of the United States Department of Commerce has been issued by the Bureau of Standards, giving all the standard nomenclature and dimensions and types for solid section steel windows. The recommendation went into effect in September, 1927, but has just been published.

The first meeting of the manufacturers was early in 1926, at which time a committee was appointed to make a survey of current practice within the industry. A conference was held April 28, 1927, and the recommendations reducing the number of varieties manufactured by 93 per cent was adopted. It was pointed out that the remaining 7 per cent of varieties covered 90 per cent of the demand.

Concrete Pavement Yardages

There is given below a tabulation of concrete pavement yardage awarded during March, 1928, together with the total number of square yards awarded for roads, streets and alleys in the year to date.

	Sq.Yd. Awarded During March, 1928	Sq.Yd. Awarded From Jan. 1 to March 31, 1928
Roads	8,746,311	18,464,520
Streets	3,380,965	6,899,921
Alleys	279,172	442,639
Total	12,406,448	25,807,080

Business Notes

SULLIVAN MACHINERY CO., Chicago, has appointed a number of new distributors, as follows: Funkhouser Machinery Co., Kansas City, Mo.; C. Taylor Handman, Cincinnati; Paul A. Pie, Commercial Trust Building, Philadelphia; H. W. Dexter, 22 Laura St., Jacksonville, Fla.; M. H. Elder Culvert & Machinery Co., Atlanta, Ga.; C. H. Ineson, Exchange Place Building, Rochester, N. Y.; Joseph C. Fiorello Co., Buffalo, N. Y.; Staata Abrams, Firemen's Building, Newark, N. J.; and Hunter Machinery Co., Detroit, Mich.

TRUSCON STEEL CO., Youngstown, Ohio, has appointed three new vice-presidents: C. I. Auten has been made vice-president in charge of sales in the standard building division. Under his charge will be sales of structural steel, steel deck roofing and transmission structures. M. T. Clark has been made vice-president in charge of sales of the steel window division, with which he has been identified for the last nine years. C. D. Loveland, formerly manager of the Pittsburgh district, is made vice-president with headquarters at Newark, N. J., to be in charge of the distribution in that state.

RUSSELL GRADER MFG. COMPANY, Minneapolis, has appointed as distributor for the state of North Dakota the Nodak Road Equipment Company, Fargo, N. D.

GLENN L. MARTIN COMPANY, Cleveland, manufacturer of airplanes, will locate its new plant in Baltimore in connection with the new airport to be established by the city. Construction of the first unit of the plant will start immediately and will cost $1,500,000. It is to be completed the first of the year and will employ about 1,200 persons.

GEORGE D. WHITCOMB COMPANY, Rochelle, Ill., announces the appointment of Ralph Rollins as sales representative in North Carolina, South Carolina and southern Virginia, with headquarters in Charlotte, N. C.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, Pittsburgh, Pa., has recently received a contract for $2,250,000 for street lighting equipment from the city of St. Louis. This contract is the fourth to be awarded in connection with the city's $8,000,000 street lighting project, and is claimed to be the largest single award ever made for street lighting improvement.

OXWELD ACETYLENE COMPANY, 30 East 42d St., New York, has taken over the exclusive distribution of the acetylene floodlights and other equipment formerly sold by the Carbic Manufacturing Company, Duluth, Minn.

KALMAN STEEL COMPANY, Chicago, has opened a branch office in Houston, Tex., in charge of H. W. Goodman, who has been transferred from the Detroit office of the company. This office will cover the states of Texas and Louisiana.

STEPHENS-ADAMSON MANUFACTURING COMPANY of Canada, Ltd., following the establishment of a manufacturing plant at Belleville, Ont., has opened branch sales engineering offices at Toronto and Montreal, with A. F. White and George H. Smith, respectively, in charge.

H. P. SIGWALT, for the past five years advertising manager of the Milwaukee Corrugating Company, has resigned and will take charge of the industrial advertising division of the Cramer-Krasselt Company, advertising agent, Milwaukee. Mr. Sigwalt has been secretary, president and vice-president of the National Industrial Advertising Association and is well known in the advertising profession. He has also been advertising manager for the Federal Motor Truck Company, the American Optical Company and the T. L. Smith Company. D. C. Smith has been appointed to succeed Mr. Sigwalt as advertising manager of the Milwaukee Corrugating Company.

WATSON-STILLMAN COMPANY, New York City, announces that H. J. Hair, formerly sales engineer handling railroad sales for the Whiting Corporation, has been appointed manager of railroad sales of the Watson-Stillman Company.

G. C. LENDON, formerly purchasing agent, United Fuel & Supply Co., Detroit, has joined the sales organization of the Milwaukee Corrugating Co. as Detroit district manager of the Fireproof Material Division.

INLAND STEEL CO., Chicago, announces the appointment of H. L. McCauley as district sales manager in Milwaukee, succeeding C. M. Easterly, resigned. Mr. McCauley has been assistant district sales manager in this office since 1924.

New Developments

Portable Acetylene Light for Construction Operations

A portable acetylene flare light has been developed by the Oxweld Acetylene Co., 30 East 42nd St., New York City. The flare light is claimed to be extremely powerful and is available in sizes ranging from an 8,000-cp. size, which weighs 115 lb. charged and stands 6 ft. 7 in. high with reflector raised, down to a small hand light.

The fuel used is acetylene produced from carbic, the latter marketed exclusively by the Union Carbide Sales Co., New York City, and handled by jobbers in principal cities. Several cakes of carbic, enough to operate the flare continuously for twelve hours, can be placed in the light at one charging.

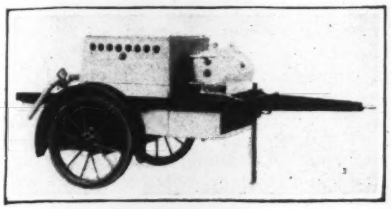
The lights operate equally well under all climatic and weather conditions, as they are equipped with a storm-proof

burner. When the light has been put into operation it needs no further attention until the charge is exhausted. In case the light is accidentally upset, the water runs out of the container and gas generation stops immediately.

There is also available a double-burner model which will furnish illumination in two directions simultaneously. This is about the size of the larger model referred to above.

New Machine Combines Asphalt Kettle and Tool Heater

There has recently been added to the line of road and street construction and maintenance equipment manufactured by Littleford Bros., Cincinnati, Ohio, an oil-burning tool heater combining with it an asphaltic cement kettle. The capacity of the heating compartment is about 15 paving tools, such as tampers, smoothers, shovels, rakes, etc. Tools

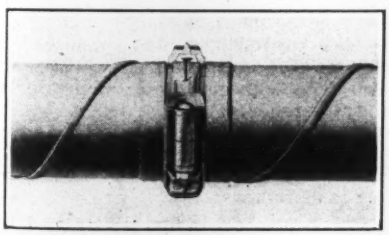


properly heated can be withdrawn in less than five minutes after they have been placed in the heating compartment, it is claimed. The asphaltic cement kettle has a capacity of 50 gal. and it is said will produce hot melted material 10 min. after the burners are started.

It is claimed that this new machine, known as tool heater No. 90, is free from smoke and sparks, making it very desirable, especially for work in congested districts. It has high-carbon steel axles with roller-bearing wheels, permitting ease of trailing.

Spiral Pipe Provided With Flexible Joints

Because of savings in time, labor and maintenance, spiralweld Toncan iron pipe, as manufactured by the Naylor Spiral Pipe Co., Chicago, Ill., has been



made available for use with the Victaulic flexible couplings. Spiralweld pipe is available with grooved ends for the couplings in sizes from 4 to 12 in. in diameter. The pipe is adapted for handling air, water, steam, oil and gas, and because of its smooth inside surface is claimed to reduce frictional resistance to a minimum.

Several advantages are pointed out for this new product: (1) unskilled labor may be used for installing it; (2) exact alignment is not necessary; (3) saving in shipping is made because of the smaller dimensions of the couplings as compared with flanges and because of the light weight of the pipe; (4) saving in space is possible, since fittings and joints may be shipped separately; (5) it has a lower maintenance cost because joints are leakproof even when subjected to severe shocks or vibrations; (6) it is easy to remove any length of pipe in a line without disturbing the remainder of the line.

Jack of 75-Ton Capacity Operated by Oil Weighs 200 Lb.

A 75-ton jack has been added to its line of hydraulic oil-power jacks by the Blackhawk Mfg. Co., Milwaukee, Wis. The new jack, known as model G 18, weighs only 200 pounds and is claimed to be lighter than any other jack of similar capacity. Equipped with special carrying handles, it can easily be moved by two men. The jack has a collapsed height of only 18 in., and a 10-in. lift. An important feature of the jack is the use of two pumps—a speed pump to quickly raise the plunger of the jack to point of contact and a power pump to raise the load.

It is said that the capacity is conservatively rated, safety being the first consideration. The load can be automatically lowered fast or slow as desired, and it is always under control. The release valve is entirely separate from the pump and prevents accidental lowering. All working parts (pumps and ball-checks) are built on the outside of the jack. An outstanding feature is the check valve unit. This unit contains both ball checks and is really the heart of the jack. It is easily removed for cleaning by simply unscrewing the pump.

Manufacturers and Trade Associations

Calendar

Annual Meetings

NATIONAL ASSOCIATION OF RAILROAD TIE PRODUCERS, St. Louis, Mo.; Annual meeting, Hot Springs, Ark., April 24-26.

AMERICAN WATERWORKS MANUFACTURERS ASSOCIATION, New York City; Annual meeting, San Francisco, Calif., June 11-14.

New Publications

Graders—GALION IRON WORKS & MANUFACTURING COMPANY, Galion, Ohio, has recently published several new catalogs describing its new motor graders. They include a new sixteen-page catalog describing the McCormick-Deering E-Z lift motor graders, and bulletins describing the company's graders built around the Cletrac, Twin City, Caterpiller and Fordson tractors.

Electric Hoists—MUNDY SALES CORPORATION, New York City, has recently published a 70-page catalog, No. 4A, which is devoted to the company's electric hoists. The hoists are illustrated and their details of construction described, while for all sizes of each type are given the line pull, speed and over-all dimensions in tabular arrangement. Three-speed hoists with sliding gear transmissions in single, double and triple drum types with and without attached swinging drum, slack line excavator hoists, drag scraper hoists, power hoists, single drum hod hoists, and mast and gaff equipment are included. About 30 pages of the catalog are devoted to illustrations and descriptions of large engineering works over the United States on which Mundy electric hoists have recently been used.

Sand Washing—THE DORR COMPANY, New York City, devotes its bulletin No. 4171 to its sand-washing equipment with a capacity of 150 tons per hour. Illustrations are shown of the sand washer installed on land and also as a part of the sand dredge machinery.

Concrete in the Petroleum Industry—PORTLAND CEMENT ASSOCIATION has published a 46-page handbook for the engineer in the petroleum industry who is called upon to use concrete. The book is divided into five parts, in the first of which is discussed the fundamentals of concrete making, in the second cementing of oil wells and the construction of reservoirs and tanks, in the third the use of concrete in refineries and in the fourth suggested specifications in addition to instructions for placing derrick foundations.

Magnets for Highway Sweeping—ELECTRIC CONTROLLER & MANUFACTURING COMPANY, Cleveland, Ohio, has recently published a pamphlet describing its road-sweeping magnets for freeing roads of nails, tacks and other metallic materials. Illustrations are given showing the method of hanging the magnet from the rear end of motor trucks.

Hydrogen-Ion Control—LAMOTTE CHEMICAL PRODUCTS COMPANY, Baltimore, Md., has published the fourth edition of its manual entitled "The A B C of Hydrogen-Ion Control." The booklet contains 124 pages, 74 of which are devoted to a discussion of the theory and application of hydrogen-ion control. The company states that the booklet has been used in a number of colleges during the past year as a reference book. The presentation has been designed to be as simple as possible so that the method can be applied by men who do not have technical training.

Business Side of Construction

Facts and Events That Affect Cost and Volume

Government Building Materials Index Shows Slight Change

The building materials index number of the United States Bureau of Labor Statistics, based on 1926, shows a decline of 4.3 points in the last year. Since March, 1926, there has been a decline of 10.1 points. Beginning with December, 1927, however, the month-to-month changes, though slight, were upward.

The March value, just issued, for all building materials is 91.0, the same as in February, 1928. The principal price rise in February occurred in structural steel.

A comparison of February index numbers for the ten great groups of wholesale commodities shows building materials third from lowest, as follows: hides and leather products, 124.9; farm products, 103.5; house furnishings, 98.3; metals and metal products, 98.4; foods, 98.0; textile products, 96.5; chemicals and drugs, 95.6; building materials, 91.0; miscellaneous, 86.8; fuel and lighting, 80.8.

INDEX NUMBERS OF BUILDING MATERIALS PRICES
(Yearly Average 1926 = 100)

	Lumber	Brick	Cement	Structural Steel	Paint Materials	Other Materials	All Bldg. Materials
1926							
Jan.	103.3	101.0	100.4	99.6	107.7	100.3	102.3
Feb.	103.0	101.7	100.4	99.6	103.4	100.4	101.8
Mar.	102.5	101.7	100.4	99.6	99.0	100.2	101.1
Apr.	100.9	101.6	100.4	99.6	95.4	99.8	100.0
May	99.9	101.6	100.4	99.6	91.5	99.5	99.1
June	99.2	101.4	100.4	94.5	96.3	99.3	98.9
July	98.4	101.4	100.4	99.6	101.1	99.5	99.4
Aug.	98.1	99.5	99.9	99.6	103.7	99.8	99.5
Sept.	98.5	97.7	99.4	102.1	102.7	99.8	99.5
Oct.	98.2	97.7	99.4	102.1	101.1	100.8	99.5
Nov.	100.2	97.5	99.4	102.1	100.5	100.6	100.1
Dec.	98.9	97.5	99.4	102.1	97.6	100.1	99.2
1927							
Jan.	96.7	98.3	98.3	102.1	96.0	97.7	97.5
Feb.	96.0	96.0	96.5	99.6	94.5	96.6	96.2
Mar.	95.0	93.6	96.5	97.0	92.5	96.4	95.3
Apr.	95.0	93.5	96.5	97.0	91.0	95.9	95.0
May	95.2	93.5	96.5	97.0	93.9	95.2	95.1
June	94.9	93.4	96.5	94.5	92.7	94.5	94.6
July	93.9	93.3	96.5	90.7	91.5	94.0	93.7
Aug.	92.2	93.2	96.5	91.9	92.5	93.0	92.9
Sept.	91.0	93.2	96.5	93.2	90.0	92.3	92.1
Oct.	92.1	93.3	96.5	91.9	87.0	91.7	91.6
Nov.	89.2	91.3	96.5	89.4	85.7	91.2	90.2
Dec.	88.0	92.2	96.5	91.9	86.5	92.5	90.4
1928							
Jan.	88.5	92.4	96.5	91.9	88.0	92.7	90.8
Feb.	88.9	92.5	96.5	94.5	85.9	93.2	91.0
Mar.	88.9	92.3	96.5	97.0	85.5	92.7	91.0

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week ended April 19, with some comparisons, total as follows:

(In Thousands of Dollars, 000 Omitted)

Week Ended	Public	Private	Total
Apr. 19, 1928	**$38,838**	**$42,613**	**$81,451**
Apr. 12, 1928	32,011	50,387	82,398
Apr. 21, 1927	24,494	50,628	75,122
Jan. 1, to date:			
1928	**336,838**	**685,189**	**1,022,027**
1927	283,985	535,328	819,313

E. N.-R. Index Numbers

Cost		Volume	
Apr. 1, 1928	**206.40**	**March, 1928**	**318**
Mar. 1, 1928	204.65	February, 1928	225
Apr. 1, 1927	209.00	March, 1927	226
Average, 1927	206.24	Average, 1927	263
Average, 1926	208.03	Average, 1926	228
1913	100.00	1913	100

March Building Contracts Average $6.70 Per Sq.Ft.

The square-foot cost of all buildings placed under contract in March averaged $6.70, compared with $7.40 in the whole of 1927 and $7.20 in the year 1926. The most expensive type is banks, with theaters next. Apartments and dwellings cost about the same and are at the foot of the list. Two-family houses cost 14 per cent less per square foot than did one-family. Prices for ten types in March are given below.

Banks	$18.80	Industrial	6.90
Theaters	10.40	Schools	6.25
Hospitals	8.30	Dwellings	4.90
Hotels	8.20	Apartments	4.75
Public	8.00	All buildings	6.70
Office	7.85		

Brick Imports Under 1927 Rate in First Two Months

Foreign brick (duty free) received at New York, which is the chief point of entry for this material, in the first two months of 1928 totaled 9,971,000. The figure for this period a year ago is 11,716,000 or 14.8 per cent higher than this year. The 1926 figure for these two months is 9,938,000, according to the Section of Customs Statistics, Bureau of Foreign and Domestic Commerce. Common brick used in New York totaled 1,314,000,000 in 1926 and 1,280,000,000 in 1927. Of these, foreign brick amounted to 7.7 per cent in 1926 and 7.3 in 1927.

IMPORTS OF DUTY-FREE COMMON BUILDING BRICK INTO NEW YORK

	1926	1927	1928
January	6,459,000	4,331,000	3,982,000
February	3,479,000	7,385,000	5,989,000
March	4,160,000	8,438,000	.....
April	5,614,000	12,239,000	.....
May	6,268,000	10,395,000	.....
June	12,817,000	11,450,000	.....
July	8,298,000	9,083,000	.....
August	17,043,000	5,583,000	.....
September	4,676,000	6,193,000	.....
October	9,644,000	4,996,000	.....
November	15,369,000	4,245,000	.....
December	8,119,000	9,688,000	.....
	101,946,000	94,026,000	.....

Belgian brick formed 79.9 per cent of the imports, Holland 19.5 per cent, with the remaining 0.6 per cent coming from the United Kingdom. For the whole of 1927 imports were as follows: Belgium 82.9 per cent, Holland 15.5, Norway 1, United Kingdom 0.5 and Denmark 0.1. In 1926 Belgium sent 70 per cent and Holland 30 per cent. Most of the Belgian brick is common, while the Holland shipments are principally face.

Belgian common brick sells for $16.50@$17 per thousand delivered to job in New York, compared with the domestic price of $17@$20. The price for Holland face brick is $26@$27 per thousand delivered, compared with a minimum of $29.50 per thousand for selected domestic face brick of the Colonial style.

Common Brick Advances One Dollar in New York Market

Except that the price of common brick in New York advanced $1, to $17@$20 per M. delivered, price changes in the last week were as insignificant as usual of late. The only other advance was in the price of cement at Seattle, up 5c. to $2.70 net. Declines occurred as follows: Pipe, 6-in., in Dallas, $1, to $52, and in Montreal $3, to $45 per ton; wood lath, New York, $1, to $8.50@$9 per M. delivered; reinforcing bars, San Francisco, 25c., to $2.25 per 100 lb., warehouse; linseed oil, Minneapolis, 2¼c., to 84¾c. for 7½-lb. gal., delivered.

Building costs generally throughout the country changed even less in March than in February, when a decline of 0.5 per cent was recorded, due to slightly cheaper lumber and labor. According to the index numbers of the American Appraisal Company, the following almost infinitesimal changes occurred: Frame and reinforced-concrete construction higher in New England; slight decline in frame and brick with wood frame in the Middle Atlantic States, and increase in brick with steel frame and in reinforced-concrete construction; frame slightly cheaper in Northwestern States and brick with wood frame up two points; brick with wood frame higher on the Pacific Coast; the general figure for the country remains 202.9.

General Notes

Residential building in March totaled $300,000,000, compared with $265,000,000 in March, 1927. The divisions in percentages are as follows: apartments, 43; dwellings, 28; two-family, 6; hotels, 6; the remaining 17 per cent is for housing developments.

New steel-pricing plan announced by Joseph T. Ryerson & Son, Inc., for deliveries within 40 miles of the Jersey City warehouse, allows definite reductions according to the size of the order, which must be confined to one or more of the eight products listed. The schedule is as follows:

Commodity	*250 to 3,999 Lb.	4,000 to 7,999 Lb.	8,000 to 14,999 Lb.	15,000 Lb. and More
Bars	$3.25	$3.10	$3.00	$2.85
Bar shapes	3.25	3.10	3.00	2.85
Structurals	3.30	3.15	3.05	2.90
Tank plates	3.30	3.15	3.05	2.90
Floor plates	5.10	4.95	4.85	4.70
Hoops	4.50	4.35	4.25	4.10
Bands	4.00	3.85	3.75	3.60
Blue-annealed sheets	3.90	3.75	3.65	3.50

*For less than 250 lb. an extra charge of 50c. per order is made.